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ECONOMETRIC ANALYSIS OF THE SUPPLY OF COTTON IN UGANDA: A CASE STUDY OF SIX COTTON ZONES

by

© GEORGE WILLIAM MUKASA-MAYANJA

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled, "Econometric Analysis of the Supply of Cotton in Uganda: A Case Study of Six Cotton Zones," submitted by George William Mukasa-Mayanja in partial fulfilment of the requirements for the degree of Master of Science.

DEDICATED

TO

MY LATE SON

JOHN K. NAMUGERA

ABSTRACT

The extent to which agricultural producers respond to changes in economic incentives has an important relationship to the level and composition of, and changes in, farm production. In this study, the factors which have contributed to the declining levels of cotton supplies in Uganda were examined for the period from 1950 to 1974. Trends in cotton acreages and production were described and analysed. Emphasis was directed toward the possible nature of competition between cotton, staple food crops, and other selected food crops grown with cotton on farmers' agricultural holdings.

Empirical insights into these issues were sought by analysing time series data for six cotton zones--East Buganda, Busoga, Teso, Lango, West Nile, and Bunyoro. Econometric analyses based on the Nerlovian partial adjustment model were applied to annual data to analyse the effects of prices paid to growers for cotton, prices of staple and other food crops, land under cultivation per agricultural holding, prices of cotton lint in the world markets, and the Double Production Programme, on the average area under cotton per 100 agricultural holdings.

Attempts were also made to examine the nature of the cotton yield function for each zone and to investigate whether or not fluctuations in cotton yields in the study zones appear to be random in nature. The analysis of acreage and yield functions used linear, double-logarithmic, and semi-logarithmic formulations of single-equation models.

The results of the analysis of the acreage response indicated

that the price paid to growers for cotton explained the greatest proportion of the total explained variation in acreage under cotton on the farmers' agricultural holdings. Almost all the estimated coefficients of this variable were significant at relatively high levels of significance, and the signs on these coefficients were consistent with theory.

The examination of the relationship between the acreage of cotton and the prices received by farmers for the selected food crops gives some evidence of a competitive relationship between cotton and the selected food crops in several zones. In some instances, the estimated coefficients of the price variables of the selected food crops were significantly different from zero; in other cases, these estimates were not significant at relatively acceptable levels of significance. Thus, the extent to which these other selected food crops may be regarded as competitive crops cannot be readily assessed with certainty. The major staple food crops--bananas in East Buganda, finger millet in Lango and Bunyoro, and cassava in West Nile--do not seem to compete with cotton in the use of resources at the farm level. This does not, however, appear to be the case with finger millet in Teso and bananas in Busoga.

Cotton yields in Lango, West Nile, and Bunyoro showed a fairly evident increasing trend over time. Fluctuations in these yields may not be entirely associated with random effects but tend to show evidence of cyclic patterns over time.

The estimated elasticities of acreage with respect to price paid to growers for cotton varied between 0.1323 and 0.9719 for the short-run, and between 0.2616 and 2.8727 for the long-run. The patterns of response of acreage to price movements was strongly related to the existence of profitable alternative crops in individual cotton zones.

The overall implication of the results of this study is that cotton acreage does respond to changes in prices paid to producers for cotton. If it is deemed desirable to increase the output of cotton, then appropriate changes in these price levels may be necessary to accomplish this.

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CHAPTER I

PROBLEM ANALYSIS AND THE RATIONALE OF THE STUDY

A General Overview and the Problem

Cotton is one of the major agricultural commodities produced in Uganda. Traditionally, this crop has been the mainstay of the country's economic expansion and growth; it is one of the prime sources of employment income and foreign exchange earnings.

The commodity was introduced in Uganda in 1904. From that year up to 1950, the country's productive efforts were directed toward cotton expansion. Production increased steadily and reached a peak of 77,330 metric tons of cotton lint in 1938. From then, and through the years of World War II, cotton declined, but thereafter made substantial recovery up to 1950.[1]

Although coffee had already been established as early as 1930, by 1950 its share in Uganda's agricultural exports was still relatively modest, accounting for just over 30 percent of export earnings. Uganda had a cotton-dominated export economy right up to 1950. Table 1.1 shows the development of cotton and its relative share in the agricultural exports from 1906 up to 1950.

During the early 1950's, coffee exports also increased in quantity

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[1]C. C. Wrigley, *Crops and Wealth in Uganda, East African Studies*, No. 12 (Kampala: East African Institute of Social Research, 1959).

and value, and for the remainder of the decade there was a two-crop export sector with export earnings from the two commodities almost equal in value. Expansion of coffee was, however, encouraged by the coffee price boom of 1953/54.[1] Cotton was then superseded by coffee; its leading position as the stable and largest source of income and foreign exchange was threatened. Over the years 1955 to 1965, cotton production fluctuated heavily around an average annual decline of 2.5 percent in output. This annual drop was commensurate with the corresponding decreases in the average area under cotton per agricultural holding. The share of cotton in total agricultural exports continued to fall during the following decade, from 30 percent of the total value of exports in 1965 to just over 18 percent in 1970. The target of 95,000 metric tons of cotton-lint, anticipated to be attained over the Plan period 1966 to 1971, was never realized.[2]

In 1971, the government declared the Double Production Programme,[3] aimed at cotton and other cash crops; the economic rationale of this declaration was to reactivate the cash crop sector as a whole, with the

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[1]The 1950's were a period of rapid economic development for Uganda. The Korean War raised world prices of commodities, encouraging Uganda's coffee exports to increase. One effect was that the export sector became coffee dominated, with coffee accounting for nearly 70 percent of the export value in subsequent years.

[2]Government of Uganda, *Work for Progress, Uganda Second Five-Year Development Plan* (Government Printer, Entebbe, Uganda, 1966/71), pp.4-12.

[3]Double Production broadly means the country's total commitment and obligations to increase production. In areas where land is plentiful, the programme aims at encouraging the producers to open more land; in areas where land is scarce, farmers are encouraged to intensify their cultivation for higher yields. The programme also involves teaching farmers to use the recommended agricultural practices.

Table 1.1

DEVELOPMENT OF COTTON AND ITS PERCENTAGE SHARE
IN THE MAIN AGRICULTURAL EXPORTS

Year	Cotton				Percent Share In Agricultural Exports (in value terms)	
	Area Under Cotton Per Holding (in hectares)	Quantity (in metric tons)	Annual Percent Changes	Value (Ug. M. shs)	Cotton	Coffee
1906	--*	93	0	--	100.0	0
1907	--	370	+ 297.3	--	100.0	0
1908	--	740	+ 100.0	--	100.0	0
1909	--	924	+ 25.4	--	100.0	0
Av.1910-19	--	5,280	+ 471.3	13.9	100.0	0
Av.1920-29	--	24,364	+ 361.2	57.9	98.5	1.5
1930	--	34,965	+ 43.0	80.4	90.0	10.0
1931	--	38,295	+ 10.0	91.9	89.5	10.5
1932	--	52,725	+ 37.2	124.9	86.3	13.7
1933	--	52,910	+ 0.3	110.0	86.1	13.9
1934	--	46,805	- 11.6	107.6	85.6	14.4
1935	--	58,640	+ 25.3	129.0	85.6	14.4
1936	--	61,420	+ 4.7	146.2	85.3	14.7
1937	--	77,330	+ 25.9	185.6	84.3	15.7
1938	--	56,795	- 27.0	134.0	82.7	17.3
1939	--	55,638	- 3.1	130.7	82.6	17.4
1940	--	67,666	+ 21.6	171.2	82.3	17.7
1941	1.34	44,143	- 35.0	116.9	83.1	16.9
1942	1.42	20,821	- 53.8	54.9	82.6	17.4
1943	1.23	35,419	+ 70.1	90.7	82.4	17.6
1944	1.34	50,425	+ 42.3	105.9	82.2	17.8
1945	1.25	42,095	- 16.6	107.8	81.6	18.4
1946	1.34	42,910	+ 1.9	124.8	81.5	18.5
1947	1.15	21,511	- 49.9	55.1	76.3	23.7
1948	1.44	72,093	+ 235.1	169.4	69.0	31.0
1949	1.33	63,332	- 12.2	150.7	54.5	45.5
1950	0.93	64,086	+ 10.0	152.0	52.6	47.4

SOURCE: Ministry of Agriculture, Entebbe, Uganda.

*(--) indicates statistics not available.

eventual objective of stabilizing Uganda's foreign revenue.

Amidst all these efforts, cotton production continued to decline both in quantity and acreage. The particularly sharp decreases recorded over the period 1970 to 1974, were a subject of growing concern among planners and government.

Comparative statistics for the traditional food crops indicate substantial increases. Both the total acreage and quantity of food crops more than doubled over the period 1950 to 1974. The average food production per agricultural holding increased from 6,931 kilograms in 1950, to 9,092 kilograms in 1974, and the production per caput remained stabilized at 1,314 kilograms.[1] This performance in the food sector was desirable in view of Uganda's population growth rate of 2.9 percent per year from 1950 to 1960.

The price movements of cash crops reveal two characteristics. Firstly, cotton and coffee prices paid to the growers tended to remain unchanged for several years before being revised upward. Secondly, when price increases occurred, they were very small compared to the corresponding changes in the cost of living. Cotton and coffee prices, in real money terms, declined by 99 and 147 percent[2] respectively between 1950 and 1974, while the prices of food crops more than tripled during the same period. Exports in the international markets experienced persistently adverse price instability over the period 1965 to 1974.[3]

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[1]Statistics are taken from the Ministry's publications, and are modified as presented in Table 1.2.

[2]Prices are deflated by the cost of living index of low income people in Kampala, taking 1965-1966 = 100.

[3]F.A.O., *Agricultural Commodity Projections, 1960-1970*, Vol. I (Rome, 1969).

Table 1.2

AVERAGE PRODUCTION PER HOLDING, PRODUCTION PER CAPUT, AND PRICE INDICES, COTTON, COFFEE, AND FOOD CROPS

Year	Average Production Per Agricultural Holding (in kilograms)			Production Per Caput (in kilograms)			Price Indices[1]		
	Cotton	Coffee	Food Crops	Cotton	Coffee	Food Crops	Cotton	Coffee	Food Crops
1950	210	59	6,931	40.0	10.9	1,288	171	233	64
1951	229	61	7,948	40.5	10.8	1,413	168	321	77
1952	219	64	7,306	39.0	11.4	1,297	160	304	94
1953	232	70	8,453	41.0	12.4	1,502	148	283	113
1954	153	71	8,436	30.0	13.6	1,498	152	390	119
1955	207	74	8,221	35.1	13.0	1,432	160	459	116
1956	201	81	8,267	35.9	14.4	1,478	137	261	113
1957	135	82	7,615	24.8	15.1	1,395	139	278	127
1958	203	79	8,240	35.0	13.6	1,422	145	278	128
1959	176	86	8,060	31.1	15.1	1,419	115	231	129
1960	166	96	7,996	27.8	16.2	1,344	117	190	131
1961	164	78	7,769	27.6	13.0	1,309	130	165	133
1962	94	96	7,623	13.4	15.8	1,256	128	169	126
1963	151	125	7,653	27.1	20.3	1,246	121	137	117
1964	170	134	7,542	28.7	21.3	1,196	96	151	107
1965	184	117	7,635	28.8	18.2	1,189	90	96	94
1966	188	117	7,535	29.8	17.9	1,155	108	100	109
1967	183	124	7,685	28.3	18.7	1,165	67	95	109
1968	142	98	9,271	21.1	14.5	1,338	74	93	122
1969	153	177	10,032	24.1	26.1	1,469	72	96	116
1970	180	155	9,826	25.0	22.5	1,421	76	105	160
1971	154	120	9,258	22.4	17.3	1,342	69	92	160
1972	146	139	9,045	21.3	20.4	1,324	72	93	178
1973	144	144	8,737	20.9	20.8	1,264	70	89	191
1974	99	120	9,092	14.7	18.1	1,376	82	86	208

SOURCE: Planning Unit, Ministry of Agriculture and Forestry, Entebbe, Uganda.

[1]Prices are deflated by the cost of living index of low income people in Kampala, taking 1965-66 = 100.

Weather conditions and agronomic practices are believed to be responsible for the annual fluctuations in cotton output. However, this long-run decline must have explanations other than weather and management, since both the acreage and the output are persistently falling.

The author believes that the cotton long-run decline is a consequence of three factors:

1. the cotton producers' response to the prices paid to growers;

2. the changes in world prices for primary products, especially for fibres; and

3. the competition cotton has faced at farm level from other crops--mainly the traditional food crops.

The Need for the Study

The poor performance of the cotton sector during the period 1950 to 1974 has propelled the need to examine in detail the supply relationships of the commodity at the farm level. This study, therefore, attempts to investigate the apparent causes of the declining supply levels of cotton. Econometric analyses, based on Nerlovian partial adjustment assumptions, are used to develop the supply response functions for the selected study areas, hereinafter called the Zones. A series of hypotheses are tested, using the multiple regression approach. The parameters derived are used to estimate the short- and long-run supply elasticities associated with the level of production and direction of response. The results are presented for each Cotton Zone.

The Objectives

The objectives of this study are:

1. to document annual changes in cotton acreages, production, and yields in Uganda between 1950 and 1974;

2. to formulate supply response functions for the Cotton Zones, based on time series data for the period 1950 to 1974;

3. to measure the short-run and long-run supply elasticities and coefficients of adjustment in order to examine the magnitude and direction of response of the cotton producers in those Cotton Zones;

4. to assess the impact of the Double Production Programme, which was declared in 1971 to boost cotton production in Uganda;

5. to examine the consistency, realism, and the validity of the developed supply functions, as predictive tools for the year-by-year changes in acreages; and

6. to investigate whether or not changes in weather have had random effects on cotton yields.

The Hypotheses

The hypotheses tested in the analysis of cotton supply response model are:

1. that the price paid to cotton growers is responsible for the declining level of cotton production in the Study Zones;

2. that cotton production, at the farm level, is influenced by the cotton export prices;

3. that there is a negatively and statistically high correlation between cotton production and food crop production;

4. that fluctuations in cotton yields (production per unit area) are caused by weather conditions; and

5. that cotton production is directly related to the Double Production Policy.

The Scope and Organisation of the Study

The Scope

The study covers six Cotton Zones, namely: East Buganda, Busoga, Teso, Lango, West Nile, and Bunyoro (see map of Uganda showing the study areas). The choice of each Cotton Zone was dictated by the fact that:

1. the Zone is one of the main cotton growing areas of Uganda;

2. producers have a distinctive staple food crop, grown along with other crops, which provides substantial income to the producers; and

3. the Zone has a farming system quite different from the farming systems of other Zones included in the Study.

Organisation of the Study

The thesis is organised in six chapters. Chapter I is devoted to the delineation of the problem and also to defining the economic rationale of the Study. Chapter II discusses the position of cotton and coffee exports in Uganda's economy and also focuses on the world cotton economy and its impact on Uganda's cotton industry. The chapter provides a description of the annual changes in cotton acreages and production. Chapter III outlines the economic theory underlying the supply response analysis and presents a brief discussion on general supply response relationships in developing countries. Chapter IV reviews the past studies

on supply response, outlines the assumptions underlying the models, and presents the models (including the data which were used in this Study). Chapter V presents the results of the analysis and discusses the realism, consistency, and validity of the models. Chapter VI provides the summary, conclusions, and some policy implications; the need for future research in this field is finally suggested.

CHAPTER II

COTTON AND UGANDA'S ECONOMY

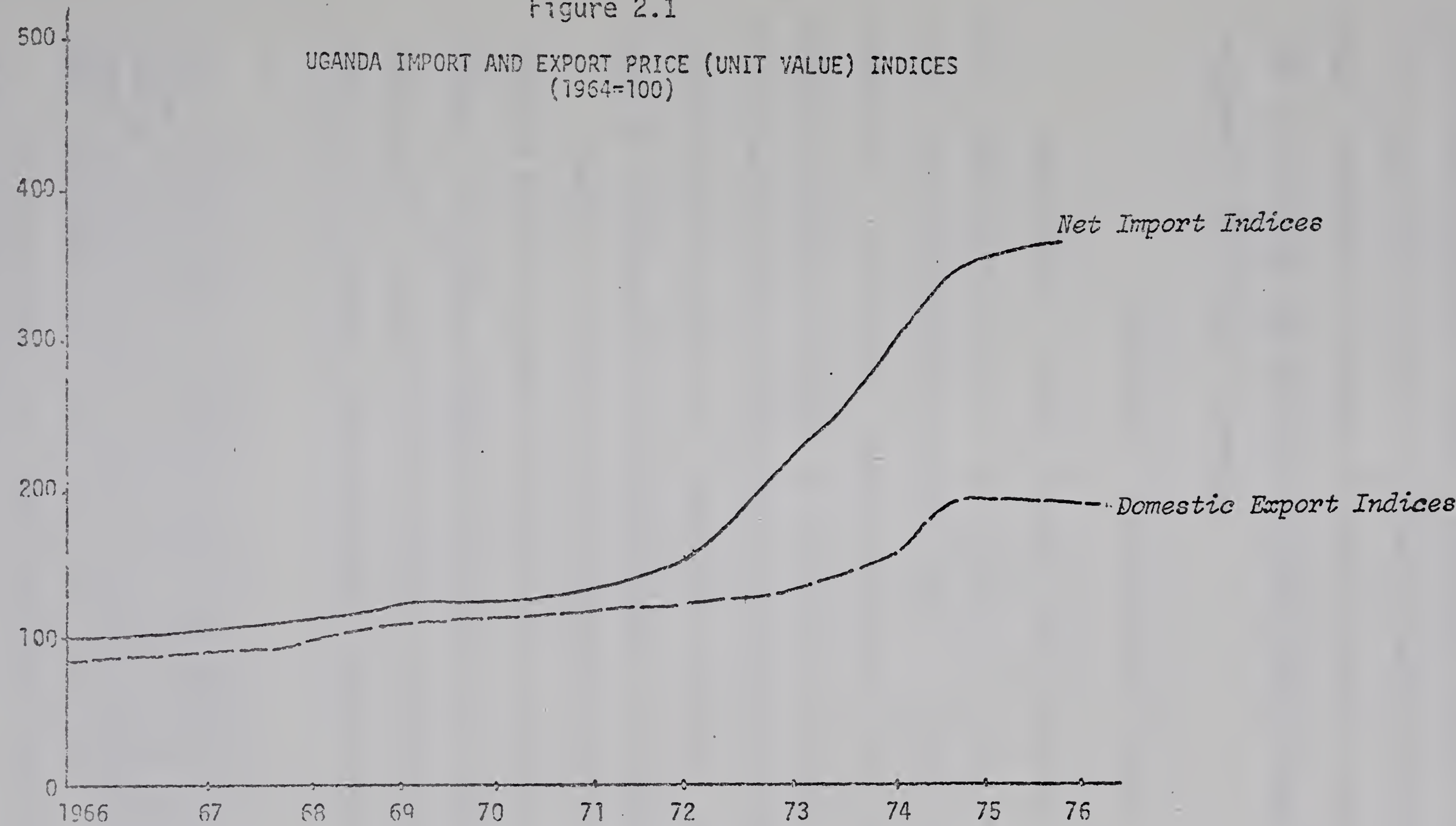
Introduction

As in many developing economies, one distinctive feature of Uganda's economy is the dependence on primary products for a large proportion of its export trade. The country's export sector is based on five principal commodities, four of which--coffee, cotton, tea, and tobacco--are agricultural, while the fifth--copper--is a mineral product. As a result of this dependence on exportation of primary products, Uganda has periodically experienced adverse terms of trade and unstable export revenues. One of the reasons for fluctuations in export earnings is that cotton, one of the country's main foreign exchange earners, has, during the past twenty-five years, faced increasing and major competition from synthetic substitutes in industrialized countries. Figure 2.1 shows price indices of exports and imports for Uganda over the period from 1966 to 1975 (1964 = 100). This figure demonstrates that over this period, and particularly from 1971 to 1975, manufactured goods' prices from industrialized countries have risen much faster than have the prices of Uganda's exports. This feature implies that, to avoid trade deficits, Uganda needs to increase production and export of exportable goods which are predominantly agricultural in order to maintain the same amount of imports.

The present chapter gives a general outline of the performance

Figure 2.1

UGANDA IMPORT AND EXPORT PRICE (UNIT VALUE) INDICES
(1964=100)



Source: Uganda Government, *The Action Programme, A Three Year Economic Rehabilitation Plan 1977/78-1979/80*, pp. 22.

of the cotton production sector. The chapter briefly discusses the role of the agricultural exports of coffee and cotton in Uganda's economic growth, documents the changes in cotton production during the period from 1950 to 1974, and then outlines the world cotton economy and its impact on Uganda's agricultural economy.

Agriculture in the National Economy

Agriculture is by far the most important sector in Uganda's economy. Eighty-three percent of the estimated 12.3 million people derive their livelihood directly from this sector. The share of the subsistence production is still high. Between 1966 and 1972 (see Table 2.1), the monetary economy contributed, on the average, 70 percent to the total Gross Domestic Product (GDP), while the remaining 30 percent was derived from subsistence production. Agriculture, therefore, remains the main basis for production and for economic growth and progress.

Uganda is a country of small-sized agricultural holdings.[1] It is estimated that the average of the more than 1.6 million agricultural holdings in relation to Uganda's cultivable land is around 3.29 Ha. The farm population per agricultural holding is about 5.5 persons.[2] For all agricultural production, the agricultural holding forms the decision-

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[1]An agricultural holding in Uganda is defined as all the land which is used partly or completely for the purpose of agricultural production (including grazing land other than communal land.) Livestock owned by the holder, even if he has no land, is regarded as a holding. Uganda Government, *Report on Uganda Census of Agriculture*, Vol. I (Entebbe: Government Printing Office, 1965), pp. 80-81.

[2]These statistics are taken from various government publications and are presented in Table 2.2.

Table 2.1

RELATIVE CONTRIBUTION OF AGRICULTURAL SECTOR TO GDP*
(in percent)

Sector	1966	1967	1968	1969	1970	1971	1972	1973	1974	1966-70 Average	1971-74 Average
Agriculture	48.9	48.3	47.8	49.0	48.6	45.8	48.1	50.6	49.2	48.5	48.4
Other Primary Sectors[a]	4.7	4.7	4.8	4.7	4.8	4.8	4.7	4.5	4.7	4.7	4.6
Industry[b]	8.2	8.3	8.4	8.4	8.7	8.5	8.3	8.0	8.0	8.4	8.2
Other Secondary[c] Services	2.7	3.0	3.2	3.1	2.9	3.0	2.7	2.6	2.8	2.9	2.7
Services[d]	35.5	35.7	35.8	34.8	35.0	37.9	36.2	34.3	35.3	35.5	36.1
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Monetary Economy	69.4	69.2	69.0	69.7	70.0	70.0	69.0	67.8	66.5	69.4	68.3
% Non-Monetary Economy	30.6	30.8	31.0	30.3	30.0	30.0	31.0	32.2	33.5	30.6	31.7

*GDP (Gross Domestic Product) is based on 1966 prices.

[a] Sectors include forestry, fishing, hunting, and mining.

[b] Industry includes crop processing, manufacturing of food products, and miscellaneous manufacture.

[c] Services include electricity and construction.

[d] Services include commerce, transport, communication, miscellaneous government, and rents.

SOURCE: Planning Unit, Ministry of Agriculture and Forestry, *Report on FAO Agricultural Statistics Seminar* (Entebbe: Statistics Section of Planning Unit, 1976), pp. 8-26.

Table 2.2

PROJECTED POPULATION, FARM POPULATION, AND LAND UTILIZATION
1950 - 1974

Year	Number of Agricultural Holdings (000´)	Number of Population (000´)	Cultivated Land		Farm Population		Averages		
			Ha (000´)	%	No. (000´)	%	Cultivated Area Per Holding (Ha)	Population Per Holding	Farm Population Per Holding
1950	926.9	4986.3	2914.7	15.4	4785.9	96	3.13	5.4	5.2
1951	932.9	5246.9	2992.4	15.9	4974.0	95	3.21	5.6	5.3
1952	946.3	5328.9	3014.0	16.0	5057.1	95	3.19	5.6	5.3
1953	962.3	5415.3	3061.9	17.2	5144.5	95	3.19	5.6	5.3
1954	979.6	5514.7	3092.8	17.4	5222.4	95	3.16	5.6	5.3
1955	989.7	5682.3	3255.6	18.3	5285.9	93	3.26	5.7	5.3
1956	1043.1	5832.9	3288.5	18.5	5505.4	94	3.15	5.6	5.2
1957	1098.2	5993.6	3461.5	19.5	5405.5	90	3.15	5.4	4.9
1958	1108.3	6421.4	3568.6	20.1	5624.8	88	3.22	5.8	5.1
1959	1143.6	6496.3	3604.7	20.3	5827.2	90	3.15	5.7	5.1
1960	1170.9	6966.9	3716.2	20.9	6103.0	87	3.17	5.9	5.2
1961	1218.2	7229.9	3812.2	21.5	6158.9	85	3.14	6.0	5.1
1962	1236.9	7504.6	4032.8	22.7	6544.0	87	3.25	6.1	5.3
1963	1263.6	7788.4	4073.5	23.0	6713.5	86	3.22	6.1	5.3
1964	1283.7	8088.5	4156.7	23.3	6745.9	83	3.23	6.4	5.2
1965	1298.4	8337.8	4198.7	23.6	7146.3	86	3.23	6.4	5.5
1966	1318.3	8600.8	4284.4	24.1	7534.3	87	3.24	6.5	5.7
1967	1344.5	8875.0	4462.9	25.1	7703.5	87	3.32	6.6	5.8
1968	1361.6	9159.1	4501.0	25.3	7913.4	86	3.30	6.7	5.8
1969	1393.7	9456.1	4614.1	26.0	8444.5	89	3.31	6.8	6.1
1970	1418.2	9806.4	4602.3	26.0	8295.4	84	3.24	6.9	5.8
1971	1468.2	10127.4	4744.6	26.7	8557.8	84	3.23	6.8	5.8
1972	1531.6	10461.5	4891.4	27.6	8703.9	83	3.19	6.8	5.7
1973	1564.0	10809.6	5038.1	28.3	8960.3	83	3.22	6.9	5.7
1974	1690.9	11174.9	5189.2	29.2	9249.1	83	3.06	6.6	5.5

SOURCE: Uganda Department of Agriculture, *Form One Report*, Various Issues (Entebbe: Department of Agriculture).

Uganda Government, *Statistical Abstracts*, Various Issues (Entebbe: Government Printing Office, 1963 - 1973).

Planning Unit, Ministry of Agriculture and Forestry, "Reports" (Entebbe: Statistics Section of Planning Unit).

making unit, and the family typically provides the labour force.

Differences in climatic zones and soil quality in Uganda facilitate a widely-diversified agricultural potential which has not yet been fully exploited. The most important cash crops are coffee, cotton, tea, tobacco, and sugarcane in that order, and these occupy about 1.4 million Ha of the most fertile land.[1] Food crops include bananas, finger millet, maize, sorghum, cassava, sweet potatoes, beans, and groundnuts. However, the popularity of these crops varies greatly from one district to another.

Data in Table 2.3 show the position of agriculture in Uganda's export earnings. Eighty-five percent of Uganda's exports consist of agricultural products. Between 1966 and 1974, the relative contribution of the dominant export crops--coffee and cotton--averaged 73 percent of the total export value. The contribution of coffee alone increased from 47.5 percent in 1966 to 72.3 percent in 1974. Cotton, however, declined both in volume and value terms, decreasing from 20.8 percent to 11.9 percent during the same period.

The economic history of Uganda during the present century can be considered a by-product of the exploitation of the natural resources which favoured the production of the two smallholder crops, coffee and cotton. Since World War II, there has been concern to encourage

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[1]In addition to these cash crops, cocoa, vanilla, wheat, and rice are grown on a limited scale, but plans are underway to expand the production of these crops to a level where they can be commercially exported as foreign exchange earners. Livestock also plays a very important role in the country's rural economy. In 1973, there were 4.7 million cattle, 0.9 million sheep, 1.9 million goats, and 0.7 million pigs. Uganda Government, *Statistical Abstract 1973* (Entebbe: Government Printing Office, 1973).

Table 2.3

POSITION OF COTTON IN UGANDA'S EXPORT EARNINGS
1966 - 1974 (in Millions Ug. Shillings)

Commodity	1966	1967	1968	1969	1970	1971	1972	1973	1974
Coffee									
Arabica	105.6	77.7	139.3	97.5	88.3	103.1	167.2	169.9	163.8
Robusta	590.1	614.3	575.3	682.5	926.1	879.2	961.1	1176.7	1486.7
Cotton, Raw	306.9	303.2	295.7	251.0	351.0	352.1	370.7	336.0	272.3
Copper	115.1	109.3	111.5	120.3	165.5	137.7	112.8	109.5	120.7
Tea	63.7	70.9	75.4	93.5	95.0	95.2	125.5	109.5	109.6
Animal Feeds	47.4	48.4	39.9	44.3	49.9	37.6	33.0	48.2	24.8
Hides and Skins	35.9	26.0	21.4	27.5	27.3	21.0	42.6	33.3	26.7
Oilseed, Nuts, and Kernels	4.8	4.9	5.0	5.3	6.4	5.5	6.3	11.9	11.5
Papain, Crude	1.8	2.3	2.4	2.6	3.0	2.6	5.5	2.3	1.8
Tobacco, Unmanufactured	13.9	24.3	15.3	19.8	18.3	24.3	18.9	13.9	9.4
Tin Ore and Concentrates	10.9	11.3	12.1	13.9	10.2	12.1	1.2	0.9	4.6
Wolfram Tungsten	3.4	3.6	3.4	3.9	2.7	3.8	3.7	3.3	4.0
Sugar*	94.5	97.2	82.5	87.0	94.9	76.2	69.9	52.0	30.9
Cotton Fabrics	69.6	62.8	45.2	45.7	55.9	43.0	45.7	31.3	13.4
Total Export Value	1463.6	1456.2	1424.4	1494.8	1894.5	1794.3	1965.0	2098.7	2280.2
Cotton Value as % of Total Export Value	20.8	20.8	20.7	16.7	18.5	19.6	18.8	16.0	11.9
Coffee Value as % of Total Export Value	47.5	47.6	50.1	52.1	53.5	54.7	57.4	67.8	72.3

*Includes Jaggery

SOURCE: Uganda Government, *Statistical Abstracts*, Various Issues.
Planning Unit, Ministry of Agriculture and Forestry, "Reports," Various Issues.

Uganda to achieve an increased role in the exportation of cotton and coffee. The failure to achieve this objective is likely to be due to several factors. These are briefly discussed below.

Uganda has not been successful in modernizing the production of export crops; even those commodities such as coffee, for which the country appears to have a natural comparative advantage, are adversely affected. Other countries have achieved a higher share of the world market for coffee apparently, primarily, by adopting relatively simple but improved levels of modern technology. The majority of Ugandans still prepare their land, plant, cultivate, and harvest their crops with the most traditional of tools. In fact, the principal inputs are land and labour. Crop yields have been relatively constant and production increases in the food crop sector have largely been through increased acreages rather than through increased yields (see Appendix IV).

A second possible factor is a consequence of domestic policies, particularly the agricultural price policy. Price levels seem not to have been sufficiently positive to induce a more rapid rate of growth of the cash crop sector. The country implemented a policy of minimum prices for agricultural products; this programme may not have been effective because increases in the levels of minimum prices have tended to be less than the rate of inflation.

A third feature concerns what one might term a negative view of policymakers toward agricultural exports. Uganda, like many developing countries, has adopted the inward-looking strategy[1] for industrialization,

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[1]Ademola Oyejide, "Strategies of Industrialization in Less Developed Countries," *The Uganda Economics Journal*, Vol. 1, No. 3 (December, 1973), pp. 292-293.

which is based on import substitution--replacement of imports of manufactured goods by domestic production for the domestic market. It seems to have been assumed that the policy of import substitution industrialization would simultaneously provide an engine of growth for the economy and ultimately solve some of the balance of payment problems. There was, therefore, relatively less emphasis placed on stimulating the export sector by providing incentives for cash crop production. These factors seem to have constrained the development of the cash crop sector in Uganda.

Government Policy Toward Agriculture

The long-term agricultural policy of Uganda[1] may be summarised as follows:

1. to achieve crop diversification, increased production of cash crops, expansion of marketing facilities, and improvement in the quality of cash and food crops;

2. to achieve increased livestock production;[2] and

3. to achieve increased industrial agricultural expansion and capital investment in training facilities and extension services.

Within these broad policy objectives, the export sector is intended to be directed toward maintaining the country's position in the world market for the cash crops of cotton, coffee, and tea. The government has pursued diversification and self-sufficiency goals aimed at the

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[1]Uganda Government, *The Action Programme, A Three-Year Economic Rehabilitation Plan 1977/78 - 1979/80* (Entebbe: Government Printing Office, 1977), pp. 53-56.

[2]Government policy to increase livestock production through ranching is only less than two decades old.

production of cash crops. Other government measures affecting the buying and selling of cotton, coffee, and tea include comprehensive legislation and central marketing institutions, namely, The Lint Marketing Board, The Coffee Marketing Board, and The Uganda Tea Authority. These institutions, besides exporting the commodities, also foster product quality and other marketing improvements.[1]

Farmers' Prices for Cotton

The prices paid to growers for cotton are administered, and normally computed, on the basis of costs. The Marketing Board estimates the world price for cotton, and then works backwards--deducting the processing expenses of the cooperative unions, the Board's administrative marketing costs, a payment to the Cotton Development Fund, and an export tax--so as to arrive at the price to be paid to the producers.[2] These deductions appear to have become so large, however, that relatively little margin is left to keep the cotton growers in what one could call profitable production.[3]

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[1]In general, export Marketing Boards have been criticised from various quarters; some of these are objections of principle and others are criticisms of the policies that have been pursued in practice by the Boards. I. Livingstone and H. W. Ord, *Economics for East Africa*, 1st ed. (London, Nairobi: Heinemann Co. Ltd., 1968), pp. 161-163.

[2]A similar procedure is followed when computing the prices paid to growers for coffee and tea.

[3]Uganda Government, *The Action Programme, A Three-Year Economic Rehabilitation Plan 1977/78 - 1979/80*, pp. 53-56.

Trends in Production of Cotton

The cotton varieties which are grown in Uganda are said to have originated from the American Upland varieties which were introduced to Uganda in 1904.[1] During many years of breeding, intensive selection, and crop acclimatization, these Ugandan varieties have completely diverged from their American Upland antecedents. Currently, there are two main varieties grown in the country--SATU and BPA.[2] These varieties are reputed to be a high quality Upland cotton which has a longer staple and yields finer yarn than do the general Upland cotton types. The Ugandan cottons are also associated with resistance to bacterial blight (a disease of cotton), and are vigorous in growth.

Production Requirements

Doyle summarises the general climatic conditions for cotton production as follows:

> . . . a mean annual temperature over 60 degrees F; a frostless season of 180 - 200 days; a minimum rainfall of 20 inches a year with suitable seasonal distribution; and open sunny weather.[3]

Cotton grows well on moderately fertile soils; the best cotton

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[1]Upland varieties comprise the most important section of *Gossypium Hirsutum*. The *Latifolium* stocks originated from central Mexico and spread northward into the United States. As these stocks spread into higher altitudes, there was selection for types that were suitable for these altitudes. The name Upland became applied in order to distinguish these varieties from the low altitude varieties. M. H. Arnold, "The Origins and Characteristics of Uganda Cotton Varieties," *Agriculture in Uganda*, ed. J. D. Jameson (Bungay, Suffolk: Oxford University Press, 1970), pp. 154-156.

[2]*Ibid.*, p. 154.

[3]B. C. Doyle, *Climate and Cotton* (Washington, D. C.: 1941), pp. 348-363.

lands are a mixture of clay and sandy loams.[1] Cotton is grown mostly in those areas of Uganda which have altitudes below 1500 meters and temperatures above 15^{0}C. Eight-five percent of the total production comes from eastern and northern Uganda, and the greatest proportion of land devoted to cotton cultivation is in Busoga, one of the Zones included in this study.

Trends in Cotton Area

Data on the two most important cash crops--coffee and cotton--and on combined food crops, are presented in Table 2.4. These data document, in summary form, the changes that have taken place in the total area planted, average area per agricultural holding, and the estimated area per capita, for cotton, coffee, and food crops from 1950 to 1974. These acreages experienced very pronounced fluctuations during this time span of twenty-five years. Cotton acreage shows the sharpest annual fluctuations during this period.

After World War II, the total area under cotton in Uganda increased from 568,000 Ha in 1948, to 864,100 Ha in 1950. During this period, the average area under cotton per agricultural holding remained constant at 1.32 Ha.[2] From 1950, and through the post-independence period to 1971, the area under cotton fluctuated sharply between 864,100 and 1,042,400 Ha. The average area per agricultural holding dropped from 0.93 Ha to 0.71 Ha during the same period. This drop represents an

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[1]John H. Martin and Warren H. Leonard, *Principles of Field Crop Production* (New York: 1949), p. 893.

[2]Data on area under cotton per agricultural holding from 1906 to 1950 are summarised in Table 1.1 (Chapter I).

Table 2.4

TOTAL AREA, AVERAGE AREA PER HOLDING, AND AREA PER INDIVIDUAL MEMBER LIVING ON FARM
1950 - 1974

Year	Total Area (in 000' Ha)			Average Area Per Holding (in Ha)			Area Per Capita (in Ha)		
	Cotton	Coffee	Food Crops	Cotton	Coffee	Food Crops	Cotton	Coffee	Food Crops
1950	864.1	110.9	2113.8	0.926	0.119	2.274	0.190	0.022	0.423
1951	771.4	109.3	2097.4	0.829	0.117	2.248	0.167	0.021	0.399
1952	768.5	115.3	2132.7	0.812	0.122	2.254	0.152	0.022	0.400
1953	883.5	119.7	2690.6	0.819	0.124	2.796	0.172	0.022	0.497
1954	865.4	123.5	2676.9	0.883	0.125	2.732	0.157	0.022	0.485
1955	767.3	135.5	2478.9	0.775	0.136	2.504	0.145	0.027	0.436
1956	668.9	153.4	2494.5	0.641	0.147	2.391	0.125	0.034	0.428
1957	749.8	196.0	2498.7	0.681	0.178	2.275	0.138	0.033	0.417
1958	874.4	200.9	2536.1	0.788	0.191	2.288	0.155	0.034	0.394
1959	734.6	213.4	2703.9	0.642	0.196	2.364	0.125	0.033	0.416
1960	614.4	229.5	2606.6	0.524	0.195	2.226	0.101	0.033	0.374
1961	839.1	245.1	2923.5	0.688	0.201	2.400	0.136	0.034	0.404
1962	730.2	254.5	2849.8	0.590	0.206	2.304	0.111	0.034	0.380
1963	814.9	255.3	2903.9	0.645	0.202	2.300	0.121	0.033	0.373
1964	864.8	261.1	3415.3	0.673	0.203	2.661	0.128	0.032	0.428
1965	907.2	293.3	3347.5	0.693	0.219	2.578	0.126	0.035	0.401
1966	880.1	335.4	2947.6	0.676	0.254	2.236	0.115	0.039	0.342
1967	870.4	336.0	3465.4	0.646	0.249	2.577	0.113	0.038	0.390
1968	827.9	252.4	3891.6	0.608	0.196	2.858	0.105	0.028	0.425
1969	844.3	281.2	3839.7	0.605	0.202	2.754	0.099	0.030	0.406
1970	881.3	245.7	3988.3	0.621	0.173	2.716	0.105	0.025	0.407
1971	1042.4	257.1	4279.8	0.709	0.175	3.016	0.122	0.025	0.423
1972	725.9	256.5	4314.7	0.473	0.157	2.816	0.093	0.024	0.412
1973	558.0	234.0	3965.6	0.356	0.149	2.536	0.052	0.022	0.367
1974	412.7	222.4	4367.9	0.244	0.132	2.583	0.042	0.019	0.391

SOURCE: Uganda Government, *Statistical Abstracts*, Various Issues (Entebbe: Government Printing Office).

Planning Unit, Ministry of Agriculture and Forestry, "Reports" (Entebbe: Statistics Section of Planning Unit).

average of 1.1 percent per year. The estimated area under cotton per capita also persistently declined, from 0.190 Ha in 1950 to 0.122 Ha in 1971. The peak acreage of 1,042,400 Ha recorded in 1971, was a result of the Double Production Programme declared by the government in that year to boost cotton production. There was a 20 percent increase over the acreage for 1970. The area under cotton per agricultural holding and the estimated area under cotton per capita increased by 14 and 16 percent respectively.

Changes in Cotton Production

Since 1920, the total annual supply of raw cotton in Uganda has ranged from a low of about 25,000 metric tons in 1930 to a high of some 85,000 metric tons in 1970. Though characterised by severe annual fluctuations, cotton production showed a definite upward trend from its introduction in 1904 up to 1938. After the production peak of 77,300 metric tons of lint was reached in the 1938 season, cotton production declined through the years of World War II, but it thereafter increased, up to the year 1950. Because cotton yields in Uganda have tended to be fairly constant, production during the period from 1950 to 1974 closely paralleled the changes in acreages. The production of cotton is shown in Table 2.5, as is the production of coffee and other food crops.

Although cotton production increased from 194,200 to 265,900 metric tons of seed cotton between 1950 and 1970, its relative importance on agricultural holdings substantially declined. The average production per agricultural holding and production per capita, declined from 210 and 40 kilograms respectively in 1950, to 180 and 25 kilograms respectively in 1970.

Table 2.5

PRODUCTION OF COTTON, COFFEE, AND FOOD CROPS
1950 - 1974

Year	Quantities (tonnes)			Averages Per Holding (Kgms)			Per Capita Production (Kgms)		
	Cotton	Coffee	Food Crops	Cotton	Coffee	Food Crops	Cotton	Coffee	Food Crops
1950	194.2	54.8	6424.7	210	59	6931	40.0	10.9	1288
1951	213.3	56.7	7414.7	229	61	7948	40.5	10.8	1413
1952	208.0	60.9	6913.8	219	64	7306	39.0	11.4	1297
1953	223.0	67.3	8134.6	232	70	8453	41.0	12.4	1502
1954	159.2	69.3	8268.6	153	71	8436	30.0	13.6	1498
1955	205.4	73.7	8136.7	207	74	8221	35.1	13.0	1432
1956	209.5	84.3	8621.9	201	81	8267	35.9	14.4	1478
1957	149.4	90.6	8362.9	135	82	7615	24.8	15.1	1395
1958	224.8	87.6	9132.9	203	79	8240	35.0	13.6	1422
1959	202.1	98.3	9217.9	176	86	8060	31.1	15.1	1419
1960	193.3	112.9	9362.9	166	96	7996	27.8	16.2	1344
1961	199.8	94.1	9463.3	164	78	7768	27.6	13.0	1309
1962	103.5	119.0	9428.3	94	96	7623	13.4	15.8	1256
1963	203.5	158.2	9671.1	151	125	7653	27.1	20.3	1246
1964	219.2	172.4	9681.6	170	134	7542	28.7	21.3	1196
1965	239.4	152.1	9913.6	184	117	7635	28.8	18.2	1189
1966	249.0	153.9	9933.4	188	117	7535	29.8	17.9	1155
1967	259.8	166.4	10332.2	183	124	7685	28.3	18.7	1165
1968	193.0	133.0	12623.3	142	98	9271	21.1	14.5	1338
1969	228.0	247.2	13981.7	153	177	10032	24.1	26.1	1469
1970	265.9	221.0	13936.2	180	155	9826	25.0	22.5	1421
1971	226.6	175.7	13592.5	154	120	9258	22.4	17.3	1342
1972	223.3	213.6	13852.8	146	139	9045	21.3	20.4	1324
1973	225.7	225.2	13664.3	144	144	8737	20.9	20.8	1264
1974	166.2	202.3	15374.2	99	120	9092	14.7	18.1	1376

SOURCE: Uganda Government, *Statistical Abstracts*, Various Issues.
Planning Unit, "Reports."

Comments on Coffee Acreages and Production

The total area under coffee (Table 2.4) increased from 110,900 Ha in 1950 to 222,400 Ha in 1974; there was a record peak of 336,000 Ha in 1967. The general trend in coffee acreage, unlike that for cotton, increased at an average rate of 2.8 percent per year. The average area per agricultural holding increased steadily from 0.119 Ha in 1950 to 0.254 Ha in 1966, but since then it has persistently declined. The per capita acreage showed a similar movement, reaching its peak of 0.039 Ha in 1966. The decline in the acreage of coffee seems due to deliberate government policy, from 1966 to 1970, designed to diversify away from Robusta coffee. During that period, there were substantial production surpluses which could not be easily disposed of under the restrictive quota system of the International Coffee Agreement. Many coffee producers diversified from coffee into other enterprises such as poultry and livestock farming. However, because coffee is a long-term perennial crop, the immediate impact of the diversification policy was not reflected in production trends. Coffee production (Table 2.5) continued to increase through the years from 1966 to 1970, but it has declined since then, particularly in 1973 and 1974. It has been suggested that this may mark the beginning of a long-term decline, as evidenced by persisitent production drops in coffee production during crop years from 1973 to 1975.[1]

Changes in the Acreage and Production of Food Crops

The area under food crops (Tables 2.4, 2.6) more than doubled during

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[1]Uganda Government, *The Action Programme*, pp. 26-27.

Table 2.6

AREA OF SOME SELECTED FOOD CROPS, 1962 - 1975
(in 100´Ha)

Year	Bananas	Sweet Potatoes	Cassava	Ground Nuts	Finger Millet	Maize	Beans
1962	649.3	254.0	264.0	249.0	823.0	171.0	274.0
1963	705.9	237.0	286.0	238.0	825.0	159.0	276.0
1964	746.2	287.0	240.0	254.0	843.0	193.0	319.0
1965	464.3	317.1	359.0	251.0	892.0	284.0	415.0
1966	638.7	432.0	543.0	280.0	892.0	306.0	423.0
1967	699.0	428.0	644.0	277.4	615.0	275.0	523.0
1968	803.4	480.0	699.0	251.5	814.0	275.0	417.0
1969	895.4	444.0	418.0	245.4	686.0	296.0	343.0
1970	909.4	444.0	538.0	250.5	582.0	300.0	373.0
1971	905.3	508.0	508.0	294.3	716.0	280.0	459.0
1972	916.5	509.0	371.0	291.0	497.0	415.0	309.0
1973	974.6	400.0	483.0	222.0	636.0	414.0	359.0
1974	1063.4	506.0	485.0	267.5	510.0	388.0	408.0
1975	1171.1	677.8	513.5	157.1	592.7	495.0	436.0

SOURCE: Uganda Government, *Statistical Abstract 1973*, p. 53.

Uganda Government, *The Action Programme*, p. 27.

the period from 1950 to 1974. Acreage planted to these crops increased from 2.1 to 4.4 million Ha. This change represents an annual growth rate of 3.0 percent. The average area per agricultural holding fluctuated slightly about a level of 2.3 Ha. The area under food crops per capita was relatively constant at a level of 0.394 Ha. Average food production per agricultural holding increased from 6,931 kilograms in 1950 to some 9,092 kilograms in 1974, while production per capita averaged 1,314 kilograms annually.

This outline of the changes in acreages and production of cotton, coffee and food crops, indicates that:

1. both the acreage and the production of cotton persistently declined during the period from 1950 to 1974;

2. coffee acreages and production increased from 1950 to 1966, but that thereafter acreages declined while production remained constant; and,

3. the acreages and the production of food crops more than doubled during the period under study.

The causes of the declining levels of cotton supplies seem to be found in the basic factors which influence supply. Some of these factors as they apply to cotton in Uganda are briefly examined below.

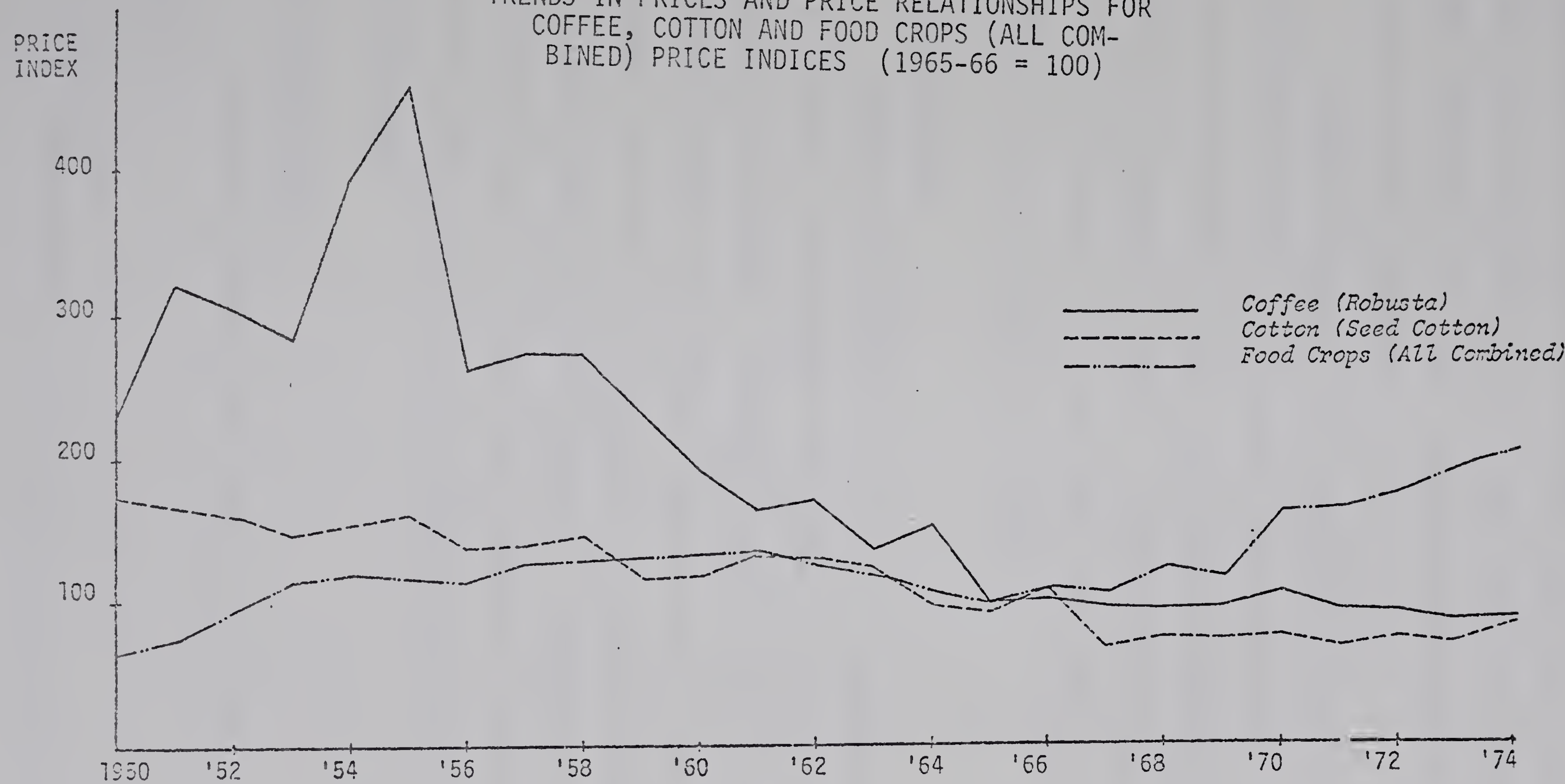
Factors Influencing Cotton Supply

Trends in Prices and Price Relationships

Figure 2.2 shows the movement of real prices received by the farmers for cotton, coffee and food crops. The essential feature shown by the figure is that the prices of export crops trended downward. The

Figure 2.2

TRENDS IN PRICES AND PRICE RELATIONSHIPS FOR COFFEE, COTTON AND FOOD CROPS (ALL COMBINED) PRICE INDICES (1965-66 = 100)



real prices for cotton have followed a declining trend since 1950. The real prices for coffee have declined since 1955. The prices of food crops exhibited a very slight upward trend from 1950 to 1961 and then rose more rapidly from 1965 to 1974.

Figure 2.3 shows the real prices for cotton, the average area per agricultural holding, and the total area under cotton. Movements in annual area committed to cotton have closely followed the changes in prices received by farmers for cotton. An implication of these features is that the improved prices of food crops have given the farmer little or no incentive to maintain production of cotton.

Production Costs

Another most important consideration regarding production levels is the farmers' profit margin--the difference between farmers' costs of production and revenues. In Uganda, the basic tools and production inputs which greatly raise yields on agricultural holdings--hoes, ox-equipment, fertilizers and chemicals--have to be imported. Since 1965, the prices of these items have increased. Consequently, producers have faced increasing and relatively high production costs which have tended to greatly reduce profit margins, and hence reduce the incentives to grow cash crops.

Land Tenure Systems

In Uganda, prior to 1975,[1] land was held under the following categories:

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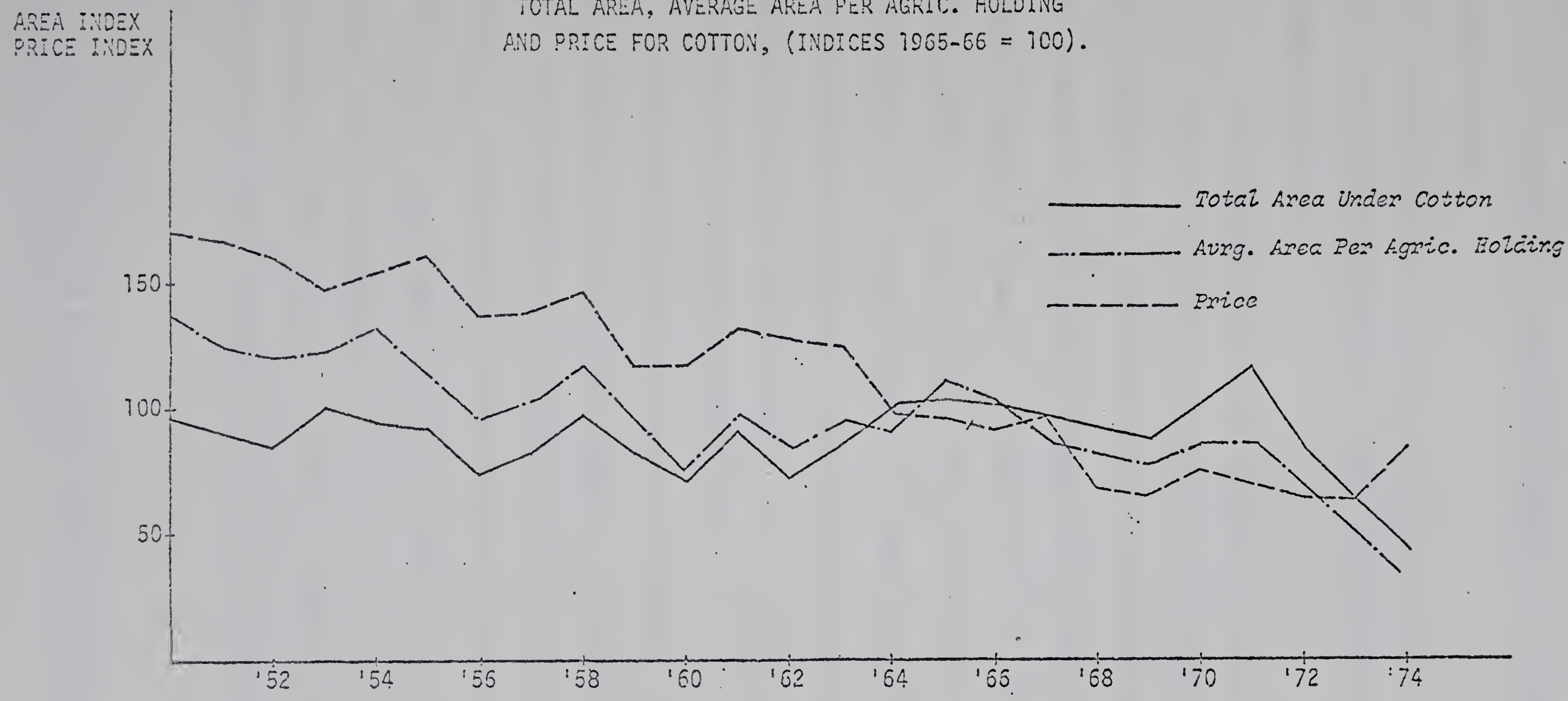
[1]All land, by the 1975 Land Decree, became public land.

Figure 2.3

TOTAL AREA, AVERAGE AREA PER AGRIC. HOLDING
AND PRICE FOR COTTON, (INDICES 1965-66 = 100).



1. Land held in registered freehold by individuals, companies and public bodies.

2. Land held in freehold by the Land Commission for Uganda on behalf of the Uganda government. This land included the National Parks and Forest Reserves.

3. The remaining land was vested in the Land Commission, and was administered on its behalf by the District Land Committees. This was known as public land, and included land demised by way of lease or license, land held under customary tenure, and vacant land. Most of this land was, however, held under customary tenure.[1] The essential feature of this system was that all long-time users (owners), whether of registered freehold or leasehold holdings, claimed rightful possession of the land and used it indefinitely. The land tenure system was so secure that even the landlord found it difficult to evict tenants if he wished to expand his own agricultural activities.

The economic implication of the system was that any response toward expansion of crop acreage tended to be associated with the existing size of the agricultural holding owned. The system had the effect of setting a limit on any intended expansion which the producer might have planned. Since these factors are expected to have an important bearing on the responsiveness of supply to price changes of individual crops, they would thus have an implication regarding the variables which should be considered in defining postulated functions for agricultural crops.

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[1]R. A. Dunbar and D. Stephens, "Social Background of Uganda," *Agriculture in Uganda*, pp. 103-105.

The World Cotton Economy and Its Impact on Uganda's Economy

World Cotton Supply

The world production of raw cotton has more than doubled during the past forty-five years. Production increased from 5.2 million metric tons in 1932, to more than 11.0 million metric tons in 1970.[1] This increase in production of about 5.8 million metric tons represents a growth rate of approximately 2.0 percent per year. Annual average production increases from 1961 to 1965, and from 1966 to 1970, were 10.8 and 11.3 million metric tons respectively; from 1970 to 1974, world cotton production rose steadily from 11.3 to 13.6 million metric tons, representing a substantial growth rate of about 6.1 percent per year.

Over the period from 1930 to 1970, cotton accounted for more than 52 percent of the total world production of major textile fibres. The major producing countries (see Tables 2.7 and 2.8) are the United States, the Soviet Union, China and India--in that order--and these countries together produce between 50 and 52 percent of the world cotton production. The remaining 48 to 50 percent is produced in the developing countries of Africa, Asia, and South America, and in other developed countries of Western Europe.

Uganda's production, which annually averages 65,000 metric tons of raw cotton, accounts for less than 0.8 percent of the total world production, 1.5 percent of the production from developing countries, and 16 to 18 percent of the raw cotton produced in Africa. The Ugandan

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[1]U. S. Department of Agriculture, *Agricultural Markets in Change* (Washington, D. C.: Economic Research Service, 1966), pp. 130-131.

Table 2.7

COTTON PRODUCTION BY REGION, 1961 - 1974
(000' Metric Tons)

Regions	1961-65 Average	1966-70 Average	1970	1971	1972	1973	1974
The World	10,826	11,389	11,370	12,839	13,365	13,522	13,611
Developed Countries	3,474	2,346	2,461	2,543	3,272	3,083	2,839
United States	3,252	2,098	2,219	2,281	2,983	2,821	2,535
Western Europe	186	170	169	163	199	158	177
Others	36	78	73	99	90	104	123
Developing Countries	4,563	5,085	4,853	5,810	5,821	5,667	5,764
Latin America	1,592	1,566	1,321	1,656	1,702	1,643	1,705
Near East	1,201	1,430	1,500	1,620	1,671	1,620	1,655
Far East	1,458	1,611	1,544	2,005	1,909	1,902	1,872
Africa	312	478	488	529	539	502	532
Centrally-Planned Economies	2,789	3,958	4,056	4,486	4,272	4,772	5,010
U.S.S.R.	1,701	2,069	2,342	2,385	2,471	2,602	2,840
China	1,064	1,864	1,692	2,081	1,778	2,147	2,147
Others	24	25	22	20	23	23	23

SOURCE: Food and Agricultural Organization of the United Nations, *Commodity Review and Outlook*, 1974-75.

Table 2.8

COTTON PRODUCTION BY COUNTRY, 1966 - 1974

(Seed Cotton in 000' Metric Tons)

Producer Country	1966	1967	1968	1969	1970	1971	1972	1973	1974
The World	31,963	31,046	33,600	33,184	34,390	36,339	38,329	38,686	39,739
Africa	3,063	2,996	3,165	3,797	3,698	3,730	3,812	3,573	3,869
Egypt	1,275	1,195	1,195	1,162	1,393	1,409	1,409	1,352	1,320
Sudan	476	560	566	661	713	711	693	548	661
Uganda	249	260	193	228	256	227	223	226	166
Tanzania	237	205	164	207	195	195	228	265	249
Other	826	776	1,047	1,539	1,141	1,188	1,259	1,182	1,475
Asia	11,957	12,862	12,536	12,338	12,771	14,702	13,808	14,666	14,890
China	5,531	5,792	5,402	5,270	5,988	6,245	5,335	6,442	6,442
India	2,991	3,447	3,186	3,156	2,862	3,774	3,492	3,579	3,642
Pakistan	1,398	1,561	1,587	1,616	1,672	2,124	2,105	1,860	1,920
Turkey	993	1,030	1,132	1,040	1,040	1,357	1,413	1,333	1,430
Iran	322	329	453	465	441	412	620	615	640
Other	722	703	776	791	768	790	843	837	816
Europe	634	578	514	588	554	551	643	579	639
Greece	260	285	228	338	328	360	395	378	356
Spain	267	198	229	180	160	124	177	140	212
Other	107	95	57	70	63	67	71	61	71
N. & S. America	7,701	6,398	8,667	7,475	7,262	7,758	9,666	9,029	8,867
United States	5,673	4,533	6,588	5,865	5,862	6,027	7,065	7,898	6,137
Mexico	1,341	1,198	1,466	1,046	862	1,026	1,045	843	1,115
Other	687	667	613	564	538	705	1,556	287	1,615
South America	2,567	2,187	2,676	3,180	3,130	2,437	2,972	3,077	2,986
Brazil	1,573	1,289	1,728	2,089	1,950	1,446	1,950	1,883	1,687
Colombia	200	276	334	357	366	364	385	386	345
Other	794	622	614	734	814	627	637	808	954
U.S.S.R.	5,981	5,970	5,945	5,708	6,890	7,101	7,296	7,664	8,410
Oceania	61	55	97	99	85	60	132	97	80

SOURCE: Food and Agricultural Organization of the United Nations, *Production Yearbook*, Vol. 28-1 (Rome: F.A.O.), pp. 117-123.

cotton varieties, SATU and BPA, are classified as medium- and long-staple varieties respectively. This feature allows the country to compete favourably in a wide range of cotton end-use markets as compared to other developing countries.

The World Cotton Trade

Expanded world consumption of cotton has been accompanied by increased world exports. From the end of World War II to 1960, world cotton exports increased from 0.9 to 3.1 million metric tons. Exports from developing countries also rose--from 0.6 to 2.4 million metric tons--during the same period.[1] Throughout the nineteen-sixties and early seventies, world exports continued to grow steadily at a rate of 2.0 percent per annum. These exports were primarily from developing cotton-growing countries and the centrally-planned economies. The 1971 upswing in the textile cycle,[2] which took place in many developed countries, and which coincided with the rise in manmade fibre prices, appears to have contributed to this steady increase. As shown in Table 2.9, the United States and the Soviet Union have dominated the export market for raw cotton. These two countries export over 40 percent of the world cotton exports. The remaining 60 percent is dominated by Mexico, Egypt, Pakistan, Sudan, and other countries of South America. Uganda's exports of raw cotton account for an average 1.8 to 2.0 percent per year of world exports.

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[1]U. S. Department of Agriculture, *Agricultural Markets in Change*, pp. 133-134.

[2]Food and Agricultural Organization of the United Nations, *Commodity Review and Outlook 1974-75* (Rome: FAO, 1975), pp. 22-24.

Table 2.9

RAW COTTON BY MAJOR EXPORTING COUNTRIES
1960 - 1974
(in 000´ Metric Tons)

Exporting Country	1960-64 Average	1965-69 Average	1970	1971	1972	1973	1974
The World	3,535	3,527	3,550	3,639	3,738	4,302	4,341
Europe	77	100	98	99	74	91	92
U.S.S.R.	386	501	516	547	652	728	762
N. & S. America	2,086	1,791	1,599	1,575	1,537	2,093	2,108
United States	1,042	800	676	899	701	1,246	1,263
Mexico	347	379	213	166	203	178	168
South America	359	400	547	334	397	415	412
Other	338	212	163	176	236	254	265
Asia	498	637	744	777	866	837	843
India	51	36	11	32	64	50	47
Iran	57	79	100	102	115	100	100
Pakistan	102	144	135	192	260	196	198
Syria	115	125	136	119	116	119	126
Other	173	253	362	332	311	372	372
Africa	488	498	593	641	609	553	536
Egypt	300	298	285	333	295	256	259
Sudan	132	135	230	239	247	232	240
Uganda	56	65	78	69	67	65	37

SOURCE: F.A.O., U.N., *Production Yearbook*, Vols. 18-28 (1964 - 1974).

The total world value of trade in raw cotton rose with the volume of world exports, increasing from the 1961-65 average of $2,247 million to $4,042 million in 1974. The flow of foreign exchange earnings into the developing countries also rose sharply from the 1961-65 average of $1,344 million to $2,194 million in 1974. The annual average for 1966 to 1970 was $1,467 million, some 9.1 percent higher than the 1961-65 annual averages (see Table 2.10).

World prices for all varieties of cotton reached exceptionally high levels in 1971. Larger volumes of exports and higher average prices led to increases in the total value of world trade in raw cotton during 1971 and 1972. The greatest increase in foreign exchange earnings accrued to the regions of Latin America whose raw cotton export-values increased by 15 to 25 percent. While most developing countries achieved increases in export earnings over the period from 1972 to 1974, Uganda and Turkey experienced severe declines during the period. The value of raw cotton exports from Uganda (see Tables 2.9 and 2.10) declined by 37 percent between 1972 and 1974. The United States and the Soviet Union maintained their 40 percent share in the total foreign exchange earnings between 1972 and 1974.

World Cotton Prices

Manmade fibres have become a major textile raw material in the past thirty years, significantly reducing the textile market share of raw cotton. World production of manmade fibres in cotton equivalent terms increased from 0.7 million metric tons in 1945, to 5.9 million metric tons in 1974. The United States alone increased its production of manmade fibres from 0.4 to 1.8 million metric tons over the same period of

Table 2.10

VALUE OF COTTON EXPORTS BY MAJOR EXPORTING COUNTRIES, 1961 - 1974
(in Million U. S. Dollars)

Exporting Countries	1961-65 Average	1966-70 Average	1970	1971	1972	1973	1974
The World	2,247	2,314	2,394	2,583	2,723	3,953	4,042
Developed Countries	664	471	451	528	520	1,039	1,088
United States	629	401	371	448	442	929	980
Others	35	70	80	80	78	110	108
Developing Countries	1,344	1,467	1,570	1,655	1,754	2,281	2,194
Latin America	516	463	442	426	509	626	525
Brazil	108	137	154	137	169	218	67
Mexico	191	121	82	63	83	145	140
Nicaragua	42	50	34	41	53	63	78
Others	175	155	172	185	204	200	240
Near East	582	714	839	945	954	1,224	1,265
Egypt	278	305	340	402	373	484	560
Syria	76	77	81	88	98	301	240
Sudan	104	137	186	198	212	229	145
Turkey	77	139	171	191	188	113	193
Others	47	56	61	66	83	97	127
Far East	86	86	75	57	59	162	151
Pakistan	53	63	50	37	35	111	91
Others	33	23	25	20	24	51	60
Africa	160	204	214	227	232	269	253
Tanzania	26	51	35	34	37	47	48
Uganda	40	42	49	51	47	48	30
Others	94	111	130	142	148	173	180
Centrally-Planned Countries	239	376	373	400	449	633	760

SOURCE: F.A.O., U.N., *Commodity Review and Outlook*, Various issues, 1974-75.

Table 2.11

COTTON EXPORT VALUE, VOLUME, AND PRICE INDICES
1950 - 1974
(Value in Million Ug. Shillings)

Year	Export Value		Volume Index		Price Index	
	Total	Cotton	Total	Cotton	Total	Cotton
1950	578.0	334.0	63	88	94	91
1951	948.0	574.0	97	97	141	155
1952	954.0	598.0	98	99	137	149
1953	672.0	337.0	72	84	107	94
1954	824.0	418.0	88	99	114	99
1955	846.0	328.0	91	77	101	99
1956	830.0	386.0	63	96	99	96
1957	938.0	350.0	71	85	94	97
1958	928.0	362.0	71	99	91	87
1959	864.0	308.0	66	94	82	79
1960	850.0	298.0	64	83	75	86
1961	888.0	334.0	60	88	76	91
1962	936.0	165.2	59	51	75	87
1963	1126.0	284.8	90	93	80	83
1964	1521.8	317.1	100	100	92	85
1965	1473.5	335.2	97	106	90	86
1966	1551.1	306.9	114	108	90	84
1967	1562.8	303.2	114	112	91	81
1968	1540.5	295.7	108	96	95	98
1969	1660.9	251.0	115	82	97	96
1970	2012.9	351.0	128	121	105	92
1971	1672.2	352.1	113	106	110	104
1972	1851.4	370.7	127	93	107	114
1973	2105.4	336.0	117	82	127	115
1974	2252.6	272.3	97	81	162	137

SOURCE: Uganda Government, *Statistical Abstracts*, Various Issues (Entebbe: Government Printing Office, 1960 - 1973).

time.[1] Prices in cotton markets continue to fluctuate as a result of the demand caused by the levels of economic activity in the textile industries and by the promotional levels of manmade fibres.[2]

A major problem facing cotton-producing developing countries centres around the continued instability of cotton price levels in world markets. This feature may encourage increased competition from synthetics. The other major feature of concern regarding competition with synthetics is the level of cotton prices. The apparent inability of cotton supplies from developing countries to sufficiently expand to meet worldwide textile demands at current price levels is one major factor contributing to the declining market share of cotton in the world textile markets. This feature has been accentuated by the relatively noncompetitive levels of cotton prices relative to those for synthetic fibres.[3]

For most developing countries, however, the individual country's relative share in the world cotton supply is so small that it is unlikely that any change in that individual country's supply will lead to any significant change in the world cotton prices. Uganda, for example, produces less than 1.0 percent of the world output of cotton. Even within the category of long-staple cottons, Uganda's production amounts to between 5.0 and 6.0 percent of world output. It is, therefore,

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[1]U. S. Department of Agriculture, *Agricultural Markets in Change*, pp. 136-137.

[2]Food and Agricultural Organization of the United Nations, *Commodity Review and Outlook 1974-75*, pp. 25-26.

[3]Alasdair I. MacBean, *Export Instability and Economic Development* (London: George Allen and Unwin Ltd., 1966), pp. 131-141.

reasonable to assume that the price elasticity of demand for cotton for individual less-developed producing countries is close to infinity, and that the individual country's cotton exports have little or no impact on the world prices. Unless developing countries involved in cotton production give first priority to competitiveness, in terms of quality and assurance of supply of cotton, they are likely to benefit only moderately from the present arrangements of the world cotton economy.

Impact of Cotton on Uganda's Economy

Economic difficulties in most developing agricultural economies are not entirely of internal origin. The problems of the world economy, such as international monetary instabilities, tend to be transmitted to the agricultural export sectors of developing countries.[1]

Uganda is very vulnerable to adverse developments in the world economy, partly because of its reliance on world markets for the sale of its major agricultural exports and the supply of its imports, and partly because the Uganda shilling is pegged to the United States dollar. Consequently, economic and international monetary upheavals in the major developed economies directly or indirectly affect Uganda's dominantly-agricultural economy. When the United States dollar was devalued in 1971 and 1973, the Uganda shilling was devalued by the same margins. This was necessary to protect Uganda's exporters; when Uganda's major suppliers in the European Economic Community and Japan substantially revalued their

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[1]Edward G. Schuh, "Income and Stability Implications of Monetary, Fiscal, Trade, and Economic Control Policies," *Farm and Food Policy Symposium* (Kansas City: Great Plains Agricultural Council Publications, 1977), pp. 69-74.

currencies, the prices of Uganda's imports from those countries increased. Agriculture tends to exhibit a relatively inelastic supply response to changes in economic conditions. Thus, such developments tend to contribute to the relative instability of export prices of agricultural products from developing countries.

MacBean[1] noted that the total value of Uganda's exports of cotton is more closely associated with their unit value than with their volume.[2] The strong and positive relationship between the total value and unit value of cotton exports suggests that instability in the total value of Uganda's cotton exports results mostly from shifts in world demand, combined with an inelastic supply of cotton. However, to a lesser extent, instability in total value is also influenced by variations in supply of Uganda's cotton exports. Since a large number of Ugandans depend entirely on cotton for their livelihood, domestic incomes are likely to fluctuate to some extent in sympathy with the fluctuations in the export economy.[3] One of the major reasons for establishment of The Lint Marketing Board was to insulate producers' incomes from the full impact of fluctuations in world prices. The success of the Board in achieving

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[1]Alasdair I. MacBean, *Export Instability and Economic Development,* pp. 142-148.

[2]The correlation coefficient (r) between the export value and the unit value = 0.896. The correlation coefficient (r) between export value and volume of cotton export = 0.603.

[3]As a source of employment opportunities, over 1.5 million family units depend on cotton for their livelihood. In addition, there is a pool of people who are hired seasonally to assist with the field management at the farm level. During the marketing seasons quite a number of semi-skilled persons are employed by the cooperative unions. Thus, any apparent change in the cotton industry must be at least associated with the domestic incomes of cotton producers.

this objective is another field that needs investigation.

Summary and Conclusion

This chapter has attempted to highlight the general role of cotton and coffee exports in Uganda's economic growth. Government policy toward agriculture has generally been summarised. The chapter has documented the changes in cotton acreages and production in order to focus on certain factors which may have contributed to the declining levels of cotton supplies. A brief discussion on the world cotton economy and its impact on the country's agricultural sector was given. The essential feature underlying this chapter has been at least partially to identify those variables which directly or indirectly affect cotton supply. The following chapter discusses in more detail certain theoretical aspects of supply analysis.

CHAPTER III

THE THEORY OF SUPPLY

Introduction

As stated in Chapter I, the principal concern of this study is to investigate the apparent causes of the declining levels of cotton production and supplies in Uganda. Analysis of the problem involves estimating acreage response functions for cotton for the selected Study Zones, and the derivation of short-run and long-run acreage response elasticities.

This chapter presents, in a general form, those fundamental economic concepts which provide basic tools with which to analyse the supply response. Emphasis is, however, given to those factors which are expected to constitute the most important data in determining aggregate supply. This chapter also presents a brief discussion of some of the factors which appear to be responsible for the wide divergences between estimates of supply elasticities in developed and peasant agriculture.

The Supply Function

Ever since Cournot[1] presented his Mathematical Model of the law of demand and supply, there has been research into the dynamics of demand

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[1]George Stojkovic, "Market Models for Agricultural Products," *Econometric Model Building*, ed. A. Wold (North Holland, 1967), p.387.

and supply relationships at both theoretical and empirical levels. Two main versions have emerged--the static and the dynamic.

Quirk defines these two versions. Regarding the static version he states: ". . . the price at which transactions take place is the equilibrium price, and the quantity of the commodity bought and sold is the equilibrium quantity of that market." In the case of the dynamic version, he posits: ". . . in any market situation, price is moved by the forces of demand and supply towards the equilibrium level for that market."[1]

By the first definition, the equilibrium is a concept which describes the state of a market at rest, while the dynamic version interprets the demand-supply relationship as an axiom, which describes an operation. The dynamic interpretation of the law gives room for explaining the processes of adjustment in production. This power of supply and demand analysis rests entirely on the accurate interpretation of the demand and supply functions.

The supply function[2] is defined as the relationship between the quantity of a commodity supplied, and those variables which affect its

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[1]James P. Quirk, *Intermediate Micro-economics* (U.S.A.: Science Research Associates, Inc., 1976), p.30.

[2]A minor distinction can be made between the supply function and the supply curve. The supply curve expresses the relationship between the quantity supplied and its own price. The curve is specified as:

$$Q_t^s = f(P_t) \qquad 3.1$$

$$f^1(P) \gtrless 0$$

where: Q_t^s = quantity of commodity supplied, and

P_t = price of the commodity

supply. From theory, the supply of a product is expected to be related to its own price, the prices of other products (substitutes and complementary products), the prices of variable and fixed input factors, and the technology employed in production. Other non-pecuniary or social factors may also affect the supply function. Depending on the economic environment, supply functions may involve other influences: for example, policy variables such as stabilization programmes, acreage allotments, and production quotas.

The supply function can be specified as:

$$Q^s_{xt} = f(P_{xt};\ P_{yt};\ P_{zt};\ P_{ft};\ T;\ B;) \qquad 3.2$$

$$f^1_x > 0;\ f^1_y < 0;\ f^1_z > 0;\ f^1_f > 0;\ f^1_t > 0$$

where: Q^s_{xt} = quantity of commodity supplied

P_{xt} = price of the commodity

P_{yt} = prices of competitive products

P_{zt} = prices of complementary products

P_{ft} = prices of fixed and variable input factors

T = technology employed in production

B = other influences

Policy variables are normally represented by dummy variables in the supply function. However, the supply function presented above assumes that when producers respond to factor incentives they can immediately adjust production levels. According to Henderson and Quandt,[1] agricultural production is characterised by long gestation periods; a change

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[1]J. M. Henderson and R. E. Quandt, *Microeconomic Theory: A Mathematical Approach*, 2nd Edition (London, Tokyo: McGraw-Hill Kogakusha Ltd., 1971), pp. 140-146.

in product prices may not be followed at once by a change in output. Unlike the demand function, it is more realistic to postulate supply relationships in which the quantity supplied depends on the levels of price in the previous period:

$$Q_t^d = \gamma_1 P_t + \gamma_0, \qquad 3.3$$

$$\gamma_1 < 0$$

$$Q_t^s = \beta_1 P_{t-1} + \beta_0, \qquad 3.4$$

$$\beta_1 > 0$$

In the above equations, the quantity demanded in period t (Q_t^d) depends upon the price in that period (P_t), while the quantity supplied depends on the price levels of the previous period (P_{t-1}) and γ_0, γ_1, β_0, and β_1 are estimated parameters.[1] The dynamic behaviour with lags, which characterises agricultural supply functions, constitutes a fundamental problem in accurately specifying and estimating supply response models. A large number of other factors may influence the aggregate supply of agricultural commodities. Some of these factors--for example, the effect of risk and uncertainty--are difficult to measure. The model builder must select those variables which, according to existing economic theory and *a priori* knowledge about the planning behaviour of producers, can be considered as the main causal factors.

Factors Affecting Supply

The preceding section outlined, in a generalized functional form,

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[1]Henderson and Quandt, *Microeconomic Theory*, pp. 142,143.

the variables which influence quantities supplied. These variables also constitute the most important data in supply analysis. This section discusses in greater detail the part played by the major causal factors in influencing the total supply of a good.

<u>Pricing and Markets</u>

In a free market economy, prices are determined by the forces of demand and supply. The price which the buyer is willing to offer for a product reflects the value which the buyer attaches to that product, while the prices received by producers in a competitive environment will, in the long run at least, be an indicator of cost relationships.

Consumers who derive higher utility from the product are prepared to pay relatively higher prices. Relatively higher prices may induce more producers to enter production of the commodity, provided that they are not restricted by barriers to entry. Pricing systems perform the task of indicating to producers how much to produce and how resources are to be allocated among alternative uses. According to Fletcher[1], an efficient pricing system:

1. ensures optimum product-mix;

2. ensures that the desired goods and services are produced at the optimum level of efficiency and cost;

3. ensures that the distribution of goods is made to the right consumers at minimum cost and delay;

4. foresees future demand and supply conditions so that the

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[1]Lehman B. Fletcher, "Pricing and Allocative Efficiency in Agricultural Development," *American Journal of Agricultural Economics*, Vol. 50, Part 2 (1968):1294-1299.

required goods and services are produced at the appropriate time; and

5. facilitates improvements in technology and may achieve a satisfactory distribution of income between producers and consumers, and other sectors of the economy.

Although few pricing structures can fulfill all these requirements at the same time, an efficient pricing system provides a measure of assurance to producers that their endeavours are rewarded.

Product-Product Relationships

The determination of competitive, complementary, and supplementary relationships among products in an area is exceedingly important in supply response analysis. Areas suitable for competing crops can be expected to have shifting patterns of production over time, to the extent that there are variations in relative product and input prices.

Heady[1] has defined the concepts of substitution and complementarity in production as follows:

> . . . two commodities are said to be substitutes or competitive, if the output of one can be increased only through the sacrifice in production of another; and two products are complementary when an increase in output of one, with resources held constant, results in an increase in the output of another product.

Competitive products are, therefore, rivals in the use of resources. The marginal rate of substitution between two competitive products is negative. For complementary products, a shift of resources from the first product to the second increases rather than decreases output of the first product. The marginal rate of substitution between complementary products is positive. Complementary relationships may

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[1]Earl O. Heady, *Economics of Agricultural Production and Resource Use*, 1st Ed. (Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1961), pp.217-233.

occur among crops because:

1. of product interaction; and

2. one product may contribute an element of production required by the second product.

Supplementary relationships exist if the marginal rate of substitution between two products is zero. This implies that, with resources constant, the output of one product can be increased without affecting the output of the other. Wherever a stock of resource services is available and cannot be absorbed entirely by the major enterprise, the possibility of supplementary enterprises may exist. Thus supplementary enterprises permit fuller employment of resources, and the size of a supplementary enterprise depends on the limiting resource, such as land, labour, or equipment. However, while enterprises may be supplementary in respect to one factor of production, they may be competitive in respect to others.

Prices of Factors of Production

The supplies of a commodity can be expected to change if the prices of the variable and fixed inputs employed in production of the commodity change. If the wage rate to be paid to farm workers increases, for example, the producer may be forced to hire fewer workers and restrict his output. However, the importance of this effect will depend on the share of these inputs in the total costs of production. Changes in input costs can be important shifters of the supply function. The cost of fertilizer and pesticides for cotton can be expected to shift the supply curve of cotton to the right or left depending on whether the prices of these inputs are falling or rising.

<u>Technology Employed in Production</u>

Improved methods of production on farmers' agricultural holdings may increase crop productivity. Walter W. Wilcox[1] points out that the determination of aggregate supply from a region also draws on two other economic principles: the first is the principle of comparative advantage, which states that a region will tend to specialize in those products for which its costs per unit of output are lowest relative to other areas; the second is the principle of enterprise combination, where the producer should attempt to combine all his enterprises in such a way that the last unit of resources used for each product brings an equal return. Basically these are guiding principles aimed at directing the producer to select and manage his enterprises in order to maximise profit. Improvement in management practices on the farm tends to lower costs of production, and can be expected to lead to a shift to the right of the supply curve.

<u>Non-Pecuniary or Social Factors</u>

Apart from profitability of agricultural enterprises, the producers' determination and willingness to pursue an agricultural enterprise may depend, to a certain degree, on non-pecuniary factors. Peasant farmers, for example, may continue to earn low levels of income on small-sized agricultural holdings, rather than sacrifice their independence and social contacts in the rural villages to seek better jobs in cities.[2]

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[1]Walter W. Wilcox, Willard W. Cochrane, and Robert W. Hendt, *Economics of American Agriculture*, 2nd ed. (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1974), pp.22-24.

[2]I. Livingstone and H. W. Ord, *Economics for East Africa*, pp. 88-89.

On the other hand, people may be willing to work under unpleasant conditions in preference to lower rates of pay. These attitudes--and the changes in them--may, therefore, affect the supply function.

Time Variable

The variable 'time' is sometimes introduced in the estimation of supply relationships to account for changes that may occur, over time, in the processes of production, and which are not accounted for by any of the variables specified in the estimating equation. The coefficient of the variable 'time' is, in this context, interpreted as a measure of autonomous growth; the researcher is implicitly making an assumption that the constant term in the equation increases or decreases steadily, but that the coefficients of the explanatory variables remain constant.[1]

However, many econometric models in regression analysis include the variable 'time' in the context of lagged variables or as a proxy for unquantifiable factors.

Dummy Variables

Dummy variables are commonly used as proxies for qualitative factors or for quantitative factors when no observations on these factors are available. Generally, dummy variables are used in measuring shifts in functions over time. The introduction of a dummy variable in a function assumes, therefore, that the constant intercept changes in different periods, while the coefficients of the explanatory variables remain constant.

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[1]A. Koutsoyiannis, *The Theory of Econometrics: An Introductory Exposition of Econometric Methods*, 2nd ed. (London: The Macmillan Press Ltd., 1968), pp.270-272.

The factors outlined above do not operate in isolation but act together, perhaps in additive or multiplicative fashion, to determine the magnitude of the aggregate supply during any time period. Sometimes, however, government policy instruments are considered to be necessary to regulate the individual influences of these factors. Regulating intervention has been extended to most spheres of the economy, including agricultural production and marketing processes.

In the following section, the effect of the legal framework on the aggregate supply is briefly discussed.

Legal Framework

Farmers make personal decisions affecting their farm holdings. These decisions sometimes involve risks and uncertainties which may be beyond the farmers' ability to offset. There are also other factors that tend to distort the operations of the market and of the price mechanism. These factors may include a lack of information among potential buyers regarding the levels of prices and transportation difficulties which may impede goods reaching the marketplace at the appropriate time.

Government often intervenes and sets rules aimed at offsetting producers' risks and uncertainties and removing some distortions from the production and marketing systems. The reasons for government intervention have been stated as follows:[1]

1. to maintain freedom and competitive position in the marketing

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[1]Richard L. Kohls and W. Downey, *Marketing of Agricultural Products*, 4th ed. (New York: Macmillan Publishing Co., Inc.; London: Collier Macmillan Publishers, 1972), pp. 179-188.

and production systems;

2. to facilitate a mechanism for dealing with unfair trade practices deemed detrimental to the society as a whole;

3. to give assistance to those entrepreneurs whose economic activities significantly contribute to the society's welfare; and,

4. to improve marketing organisation and methods.

More simply, the fundamental role of government should be to ensure that gains from production activities are made and fairly distributed among the citizens.

The role of government in the marketing of agricultural commodities, particularly for export products, in many developing countries involves almost total control. This is because governments in those countries have typically derived most of their income for the country's economic expansion plans from taxing the export of agricultural products. Examples are coffee and cotton in Uganda, cocoa in Ghana and Nigeria, and sisal in Tanzania--to mention just a few--which are under complete marketing control of these governments.

Some Measures of Supply Response

Elasticity of Supply

The elasticity of supply shows the speed and magnitude of supply adjustment in response to changing product prices. The concept of elasticity of supply is defined as the percentage change in the quantity supplied associated with a percentage change in price.

$$\varepsilon_s = \frac{\delta Q_i}{\delta P_i} \cdot \frac{P_i}{Q_i} \qquad 3.5$$

where: ε_s = elasticity of supply with respect to price for good i .

The magnitude of the elasticity of supply depends on the mobility of resources in the production processes, the cost structure of resources employed, the ease of entry and exit by producers, and the time span.[1]

Empirical analysis has indicated that the long-run elasticities of supply are larger than the short-run elasticities, but that the elasticities for agricultural commodities are relatively low. Tweeten[2] has pointed out that the elasticity of supply tends to be highest for commodities which, (1) comprise a small proportion of farm production; (2) can be produced under a wide range of resource conditions; (3) have alternatives which are substitutable at farm level; and (4) have relatively short production periods. Estimates of supply elasticities can be useful in agricultural policy formulation, since these parameters measure the ability of farmers to adjust their production to changing economic conditions.

Coefficients of Adjustment

The Nerlovian partial adjustment hypothesis uses a lagged form of a regression model which is based upon technological and institutional barriers to immediate response to economic incentives. Regression equations constructed under the partial adjustment hypothesis include a lagged dependent variable as an explanatory variable. The coefficient of

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[1]J. N. Ferris, "Equilibrium and Overall Adjustment," *Agricultural Market Analysis*, V. L. Sorenson, ed. (Menaska, Wisconsin: George Bente and Co., Inc., 1964), pp. 219-225.

[2]Luther G. Tweeten, "Discussion Paper on Supply and Prediction by Regression and Indirect Formulation," *Economic Models and Quantitative Methods for Decisions and Planning in Agriculture*, E. O. Heady, ed. (Ames: Iowa State University Press, 1971), pp. 276-280.

adjustment is obtained by subtracting the statistically-determined coefficient of the lagged dependent variable from one. The meaning attached to this coefficient is that it indicates the rapidity of supply adjustment to changes in economic conditions.[1] The measure is widely used in models which involve adaptive expectations[2] and partial adjustment.

The two parameters outlined above--elasticities and coefficients of adjustment/expectations--have been used as a basis for analysing supply response in both developed and peasant agriculture. However, there have been marked divergences between the estimated responses obtained in studies of agriculture in developed countries and similar findings for peasant agriculture. The following section of this chapter briefly reviews some of the factors apparently responsible for the divergences.

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[1]Assuming the Nerlovian Supply Model,

$$Y_t = \hat{\gamma}\alpha_0 + \hat{\gamma}\alpha_1 P_{t-1} + (1 - \hat{\gamma})Y_{t-1} + V_t$$

where: $\hat{\gamma}$ is the coefficient of adjustment.

Consider that $\hat{\gamma}\alpha_0 = \beta_0$; $\hat{\gamma}\alpha_1 = \beta_1$ and $(1 - \hat{\gamma}) = \beta_2$, where β_1 and β_2 are the estimated coefficients of the Nerlovian equation structure.

(i) If $\beta_2 = 0$, then $(1 - \hat{\gamma}) = 0$ and $\hat{\gamma} = 1$: this implies that adjustment to the desired level of Y_t is completed.

(ii) If $\beta_2 = 1$, then $(1 - \hat{\gamma}) = 1$ and $\hat{\gamma} = 0$: this implies that there is no adjustment at all. Thus, from (i) and (ii) we can deduce that $\hat{\gamma}$ lies between 0 and 1, i.e. $0 < \hat{\gamma} \leq 1$.

For the adjustment hypothesis to apply, $\hat{\gamma}$ must lie between 0 and 1. Marc Nerlove and William Addison, "Statistical Estimation of Longrun Elasticities of Supply and Demand," *Journal of Farm Economics*, Vol. 40, No. 3 (August, 1958):861-880.

[2]Roger Waud, "Misspecification in the Partial Adjustment and Adaptive Expectations Models," *International Economic Review*, Vol. 9, No. 2 (June, 1968):204-216.

Supply Response in Peasant Agriculture.

The theory of supply assumes that producers are profit maximizers. They respond to, and then adjust their production levels to, changes in the price levels of goods and services. Supply functions are based on the assumption that profit motives guide efforts in production processes. Under the above assumption, the elasticity of supply in agriculture is expected to be significantly positive.

In the case of developing countries, some economists contend that the typical supply response is positive. Others argue that the response is perverse, in the sense that increased prices result in smaller quantities sold to market. Still others maintain that institutional constraints surrounding rural villages in developing countries are so limiting that no significant response to price is likely to be observed.[1] They argue that since developing countries still accommodate high illiteracy rates, poor communications, and complete lack of commercial sophistication, producers in peasant agriculture cannot take advantage of the changes in relative price and market prospects of different enterprises. These effects tend to slow down production adjustments in response to economic changes. Supporting this view, researchers have gathered and analysed data showing a high correlation between economic backwardness and a low level of achievement motivation.[2]

The author believes that there is now enough evidence to cast

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[1]Herman M. Southworth and Bruce F. Johnson, eds. *Agricultural Development and Economic Growth* (London: Cornell University Press, 1970), pp.399-402.

[2]Gerald M. Meier, *Leading Issues in Economic Development*, 3d ed. (London, New York: Oxford University Press, 1976), pp.550-554.

doubt on the views expressed about the non-responsiveness of supply to relative price movements in peasant agriculture. There are, however, a number of factors responsible for the wide differences which exist between supply responses in developed agriculture and similar findings in peasant agriculture. These factors are reviewed below.

Lack of Data

The methodological approaches used to derive supply elasticities range from simple linear regressions to sophisticated linear programming models. Generally there is a dearth of reliable statistical data on a wide range of economic variables essential for supply response analysis in peasant agriculture. Since the nature of any econometric model which is applied is dictated by the availability of data, price coefficients for simple regressions which have typically been applied in analysing peasant agricultural economies are likely to underestimate the true values of the elasticities. The more accurate the required variables included in estimating a supply response function are, the more significant the estimated regression coefficients are likely to be.

Researchers in supply response studies in developing countries are sometimes forced to use inappropriate deflating indices which are expected to reflect changes in the general price level, such as cost of living and consumer price indices. These indices tend to include the prices of a large number of commodities. Sometimes they include the price of the commodity under investigation as a component; however, deflating a price series by an index which contains that series as a component may bias the price regression coefficients and, hence, supply elasticities. The nature and magnitude of price coefficients differ

with the deflator used, as pointed out by Tomek.[1]

Aggregation of Models

Another important aspect responsible for variations in estimated elasticities from different studies between developed and developing agricultural economies, is concerned with the level of model aggregation. In many studies of supply response in developing countries, response models have tended to be aggregative in the sense that they represent wide areas, and sometimes the area of reference is the whole country. Often the crop under study may not be a dominant crop in some of the areas covered by the model. As Krishna[2] has indicated, net regression coefficients are influenced by the dominance of the crop, whether it is a subsistence or a commercial crop. These factors are important when interpreting the elasticities of supply with respect to price, both in developed and peasant agricultural economies.

Use of Acreage Instead of Output (Quantities)

While it is possible to argue that responsiveness of acreage to price movements is positive and high, the responsiveness of output (quantities) to price movements may be very low, or even zero. Realized agricultural production may differ substantially from intended agricultural production levels because of the influence of weather and other

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[1]William G. Tomek, "Distributed Lag Models of Cotton Acreage Response: A Further Result," *American Journal of Agricultural Economics*, Vol. 54, No. 1 (February, 1972).

[2]Southworth and Johnson, eds., *Agricultural Development and Economic Growth*, pp.514-532.

intermediate factors which affect the crop between planting, harvesting, and sale periods. When a farmer has planted his crop, he can do very little, apart from changing his management practices, to adjust his output in response to any changing conditions in the economy. Since response studies are primarily interested in the intentions of the producer as expressed by planned production, realised output response to price changes may not fully reflect the behaviour of the producer.[1] Actual planted area may be a better index of intended production than are the realised quantities.[2]

The main disadvantage of using acreage as a proxy for output is that it may be more methodologically sensible to regard acreage as the land input in the production process. Conventional production theory, then, would posit that the derived demand for an input such as land (acreage) is a function of expected production (or, in some formulations, output prices) and all input prices, including the price of land. However, this study--as is the case in nearly all supply response studies--uses actual acreage under cotton as an index of intended cotton production, partly because acreage is thought to be more directly under the farmers' control than is realized output, and partly because of data availability.

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[1]Jere R. Behrman, "Price Elasticities of the Marketed Surplus of a Subsistence Crop," *Journal of Farm Economics*, Vol. 48, Part 1 (1966):875.

[2]Pan A. Yotopoulos and Jeffrey B. Nugent, *Economics of Development, Empirical Investigations*, 1st ed. (Hagerstown, New York; London: Harper and Row, Publishers, 1976), pp. 136-137.

Summary and Conclusion

This chapter has outlined the economic concepts basic to supply response analysis and has discussed those variables which constitute the most important data in the study. It has been emphasised, however, that these variables do not operate in isolation, but simultaneously, and ultimately determine the aggregate supply. The chapter has presented a brief discussion arguing that the response of supply to price in peasant agriculture is normal and a justification for the use of actual planted area as an index of intended production rather than the actual quantities produced or sold.

In order to establish valid conclusions about the responsiveness of aggregate supply to price movements, we need accurate data on all the variables which constitute the supply function; we also need sound analytical techniques which depict the actual planning behaviour of producers. The following chapter outlines the analytical techniques used in the study.

CHAPTER IV

ANALYTICAL TECHNIQUES

Introduction

Many quantitative studies on supply relationships in both developed and smallholder peasant agricultures have been conducted for a wide range of agricultural commodities. The purpose of these studies has been to examine how actual or planned agricultural output has been related to a number of important factors, such as prices, technology, and weather, as these have changed over time. It is believed that the extent to which farmers react to changes in these factors has an important bearing on the level, composition, and changes in farm production. Of these factors, the levels of prices are of particular interest since they are expected to be key variables in explaining the magnitude and nature of short- and long-run supply responses.[1]

This chapter seeks to summarise the major features of the present state of knowledge and thought on supply and acreage responses in smallholder peasant agriculture. The chapter also provides an outline of the assumptions underlying the analytical techniques used in this study and presents the models and the data used in this study of acreage response.

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[1]The effects of these influences can be investigated by holding other variables that enter the supply function constant; that is, by estimating the partial regression coefficients of the price variables in a multiple regression of output on all relevant factors.

Some Studies of Supply and Acreage Response

Efforts devoted to the establishment of the nature and magnitude of supply responses in agriculture under various economic environments generally indicate positive but highly inelastic supply functions.

The study by Johnson[1] on the nature of supply functions in agriculture, covering the period from 1927 to 1946, and using United States agricultural data, revealed some fundamental notions on the supply behaviour in agriculture. Johnson argues that the inelasticity of agricultural supply functions in agriculture basically rests on the conditions of supply of input factors. He points out that, particularly in periods of declining prices, many agricultural inputs are relatively inelastic in supply and that this feature leads to relatively inelastic supply functions for agricultural products being even more pronounced in period when prices are declining.

Krishna[2] has estimated supply elasticities for a large number of annual crops in India and Pakistan. His studies generally yielded plausible and internationally-comparable results. The short- and long-run elasticities estimated for cotton and maize ranged between 0.4 and 0.7, and 0.56 and 1.62, respectively. Estimates by Nerlove[3] for the same

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[1]D. Gale Johnson, "The Nature of Supply Functions for Agricultural Products," *Readings in the Economics of Agriculture*, Karl A. Fox and D. Gale Johnson, eds. (Homewood, Illinois: Richard D. Irwin, Inc.; Georgetown: Irwin-Dorsey Ltd., 1969), pp. 247-271.

[2]Raj Krishna, "Farm Supply Response in India-Pakistan: A Case Study of Punjab Region," *Readings in the Economics of Agriculture*, pp. 78-88.

[3]Marc Nerlove, "Estimated Elasticities of Supply of Selected Agricultural Commodities," *Journal of Farm Economics*, Vol. 38 (1956):496-509.

commodities in the United States ranged between 0.3 and 0.7, and 0.8 and 0.9, respectively. These studies emphasized that price was the most important factor in influencing changes in acreages for cotton and maize. Their model specifications followed the Nerlovian adjustment hypothesis.

From his study on the supply response for cotton in Uganda, using regional acreage data for the period 1945-66, Alibaruho[1] concluded that cotton production in Uganda is fairly responsive to changes in producers' prices, and that the magnitude of supply response varies from region to region. The supply elasticities estimated from this study ranged between 0.0193 to 0.2695 for the short run, and 0.0345 to 0.6306 for the long run. These elasticities were smaller, generally, than those Krishna and Nerlove had estimated. However, some possible limitations that might have been responsible for this unresponsiveness of acreage to price movements can be noted. The study, in the first place, used aggregative regional data. The use of such data might have concealed differential regional crop alternatives. The study did not include the variable of land in the response model. The land tenure systems prevailing in Uganda may be a principal constraint to crop expansion.

Malima's[2] study of cotton production in Tanzania during the period from 1953 to 1969 concluded that production of this crop was significantly and positively related to expected producers' prices. The specification

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G. Aliberuho, "Regional Supply Elasticities in Uganda's Cotton Industry and the Declining Level of Cotton Output," *East African Economic Review*, Vol. 6, No. 2 (Nairobi: 1974), pp.35-55.

Nighoma A. Malima, "The Determinants of Cotton Supply in Tanzania," *Economic Research Bureau* (Dar es Salaam: Dar es Salaam University Press, 1971).

of the supply response model was similar to the Nerlovian expectation model. The estimated short- and long-run acreage elasticities were 0.68 and 2.44 respectively. The result of this study suggested that cotton acreage may be considerably responsive to changes in its own price, particularly in the long run.

Tweeten, Strickland and Plaxico,[1] using a linear programming approach, estimated cotton supply elasticities in the United States. The results from their study indicated that cotton production was highly responsive to producers' price changes. The elasticities computed ranged between 0.12 and 8.79, with an average of 3.12. These estimates were later considered by Tweeten and Quance[2] to be unrealistically large as predictors of the short-run cotton responses. Shumway and Chang,[3] evaluating the reliability of linear programming methods for estimating supply elasticities, arrived at a similar conclusion.

Considerably more research appears to have been done on the responsiveness of acreage to price movements than has been done on output or market supply. Olayide,[4] using data on Nigeria's main commodity exports

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[1]Earl O. Heady, ed., *Economic Models and Quantitative Methods for Decisions and Planning in Agriculture* (Ames: The Iowa University Press, 1971), pp.280-281.

[2]L. G. Tweeten and C. L. Quance, "Comparability of Positivistic and Normative Supply Elasticities for Agricultural Commodities," *Policies, Planning and Management of Agricultural Development*, IAAE, ed. (Oxford: Institute of Agrarian Affairs, 1971), pp.451-458.

[3]C. Richard Shumway and Anne A. Chang, "Linear Programming Versus Positively Estimated Supply Functions: An Empirical and Methodological Critique," *American Journal of Agricultural Economics*, Vol. 59, No. 2 (May, 1977):344-356.

[4]S. A. Olayide, "Some Estimates of Supply Elasticities for Nigeria's Cash Crops," *Journal of Agricultural Economics*, Vol. xxiii, No.3 (September 1972):263-275.

for the period from 1948 to 1967, investigated how actual output responds to changes in the relative prices of commodities--the results were not conclusive. The estimated output elasticities for cotton, for example, varied between 0.002 and 0.295, and were based on regression coefficients which were not statistically significant.

Supply responses for perennial crops have also recently received attention. Much of the recent research on perennial crop supply responses has related to commodities produced in tropical Africa, such as coffee, cocoa, and sisal. The supply models which have been used to estimate supply responses for perennial crops have been characterised by considerable lag-structures so that the estimating model explains not only the planting processes but also the long gestation periods and the gradual deterioration of the productive capacity of perennial plants.[1] Elasticities of supply estimated for Kenyan smallholder coffee and Ghanian smallholder cocoa, are presented in Table 4.1. These estimates also suggest that perennial crop production is price responsive in both the short and long run.

From the above review of some of the studies relevant to this analysis, the following features may be observed:

1. there is evidence of positively sloping but generally relatively inelastic supply functions in smallholder agriculture;

2. price changes for agricultural products can be regarded as appropriate signals that elicit behavioural responses in smallholder agriculture and, therefore, profit motives may be regarded as firmly

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[1]Ben C. French and Jim L. Matthews, "A Supply Response Model for Perennial Crops," *American Journal of Agricultural Economics*, Vol. 53, No. 3 (August 1971):478-490.

Table 4.1

SOME ELASTICITIES ESTIMATED FOR COTTON, COFFEE, AND COCOA BY VARIOUS STUDIES

Commodity/ Researcher	Country of Investigation	Year	Period Covered by Study	Elasticity		Type of Model
				Short Run	Long Run	
Cotton						
Alibaruho[1]	Uganda	1972	1945-66	0.25	0.63	Nerlovian
Malima[1]	Tanzania	1971	1953-69	0.68	2.44	Nerlovian
Krishna[2]	India	1963	1922-43	0.59	1.08	Nerlovian
Krishna[2]	India	1965	1948-61	0.61	1.33	Nerlovian
Krishna[2]	India	--	1922-41	0.72	1.62	Expectation
Diejomaoh[1]	Nigeria	1972	1950-64	0.67	--	Nerlovian
Nerlove[2]	United States	1958	1909-32	0.34	0.67	Nerlovian
Tweeten[2]	United States	--	--	0.40	3.12	Normative
Cocoa						
Bateman[1]	Ghana	1965	1946-62	0.32	0.87	Expectation
Bateman[1]	Ghana	1968	1946-62	0.77	1.28	Expectation
Coffee						
Maitha[1]	Kenya	1970	1946-64	0.20	0.56	Expectation

SOURCE: [1]Gerald K. Helleiner, "Smallholder Decision Making; Tropical African Evidence," *Agriculture in Development Theory*, Lloyd G. Reynold, ed. (London, New Haven: Yale University Press, 1975), pp. 30-43.

[2]Raj Krishna, "Agricultural Price Policy and Economic Development," *Agricultural Development and Economic Growth*, H. M. Southworth and B. F. Johnson, eds. (London: Cornell University Press, 1970), pp.506-507.

established among peasant producers;

3. the Nerlovian expectation and adjustment models, if well specified, tend to generate estimates of significant and responsive short- and long-run elasticities of supply;

4. there is some indication that the linear programming approach as a method for estimating supply functions tends to overestimate supply elasticities; and

5. estimates of cotton own price elasticity of supply tend to be elastic in the long run.

Table 4.1 provides a summary of elasticities estimated for cotton, coffee, and cocoa by various studies of response in tropical Africa, Asia, and the United States.

The Empirical Discernment of the Partial Adjustment Model

An adaptive expectations model was developed by Cagan in 1956.[1] According to Cagan's original formulation, expectations are revised in proportion to the discrepancy associated with the previous levels of expectations. In 1958, Nerlove[2] incorporated Cagan's model into his partial adjustment hypothesis.

A basic difference between the adaptive expectations lag model and the partial adjustment model is that the former reflects the manner

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[1]For an illustration of the expectations model as originated by Cagan, see Arnold Zellner and Martin S. Geisel, "Analysis of Distributed Lag Models with Applications to Consumption Functions Estimation," *Econometrica*, Vol. 38 (1970), pp.865-888.

[2]U. S. Department of Agriculture, "Distributed Lags and Demand Analysis for Agricultural and Other Commodities," *Department of Agriculture Handbook* No. 141 (Washington, D.C.: U. S. Government Printing Office, 1958).

in which past-observed values determine the expected values, while the latter is at least partially based on the existence of technological, institutional, and/or psychological constraints which permit only a proportion of the intended level of production to be realised during a specified production period.[1] The Nerlovian partial adjustment hypothesis has been widely applied to agricultural data to estimate demand and supply functions. The following section attempts to review the general applicability of the Nerlovian partial adjustment hypothesis to Uganda's cotton production data.

Applicability of the Model to Uganda Cotton Data

The following information, derived from growers' expectations and adjustments for cotton prices and acreages, provides some basis for construction of a response model.

During the period from 1953 to 1969, it was the policy of the

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[1]In the partial adjustment model, the desired value of the dependent variable follows the equation:

$$Y_t^* = \alpha_0 + \alpha_1 P_t + \varepsilon_t; \qquad 4.1$$

where: $E(\varepsilon_t) = 0$, $E(\varepsilon_t^2) = \sigma_\varepsilon^2$, and $E(\varepsilon_t \varepsilon_{t-1}) = 0$

and: Y^* = acreage of the crop desired

P_t = the observed price

ε_t = random residual

Hence, where only a fixed percentage of the desired adjustment is accomplished each period, that is, where (using the symbols of footnote[1] on page 56):

$Y_t = Y_{t-1} + \beta(Y_t^* - Y_{t-1})$; and $0<\beta\leq 1$, one obtains the acreage adjustment model as: $Y_t = \beta\alpha_0 + \beta\alpha_1 P_t + (1-\beta)Y_{t-1} + \beta\varepsilon_t$ 4.2

Marc Nerlove, *The Dynamics of Supply, Estimation of Farmers Response to Price* (Baltimore: John Hopkins Press, 1958), pp. 240-242.

Lint Marketing Board (LMB) to announce a price (called the 'minimum price') at the beginning of each planting period. This price, provisionally considered as the growers' price at harvesting time, was based on a very conservative estimate of the expected export prices which would be realised for the crop in the international markets. At harvesting time, a final cotton price was announced. This price, which typically was substantially higher than the minimum price, was based on information concerning the actual export prices for cotton, the expected levels of cotton production, and on government stabilization measures. This dual pricing system was abolished in 1970.

The present policy is that a single minimum cotton price is announced during the planting period, which extends from May to August each year. Usually the price is announced in the month of July, to coincide with the government's fiscal year. However, this date does not appear to be sufficiently early to enable the growers to adjust their production plans to any current price change. A large proportion of growers must base their decisions on their expectations of price. It is likely that the expected price has a relationship with the last observed price--that is, with the price of the previous season.

While it may be assumed that, given the necessary incentives, farmers aim at achieving maximum levels of intended crop production, there are complementary factors which may act as barriers to achieving desired production levels. Such factors may be institutional factors such as labour adjustments and technological constraints such as storage facilities. Sometimes farmers may adjust their behaviour to decrease the risk of crop failure by decreasing crop acreages, even if price expectations may be relatively high. These factors may permit only a proportion

of the intended acreage level to be realised during any cotton season.

Assumptions Underlying the Models

In any study, the assumptions underlying specific types of model formulations must be recognised.[1] The following general features and assumptions underlie the models specified in the next section:

1. A large proportion of agricultural holdings in Uganda, and particularly in the Cotton Study Zones, practise mixed agricultural systems. These systems have evolved over time and are now relatively stable. Thus, adjustment to new incentives is likely to be constrained by lags.

2. For all production purposes, the agricultural holding is regarded as the decision-making unit.

3. The cotton production sector is characterised by free entry and exit. Producers can enter or leave the industry depending on their economic goals and desires.

4. Cotton is a smallholder's crop, produced on small agricultural holdings, and the members of the family typically provide the labour force.

The Acreage Response Model[2]

Specific assumptions regarding this model are:

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[1]D. R. Colman, "A New Study of United Kingdom Cereal Supply," *Journal of Agricultural Economics*, Vol. xxi, No. 3 (The Agricultural Economics Society, September 1970):333-343.

[2]Note the slight changes in terminology used in all following sections from that used by Nerlove which was outlined in pp. 56 and 69 of this study.

1. The desired acreage (denoted by A_t^*) which growers commit to cotton production in any one season, depends on the observed cotton price, the observed prices of other crops (substitutes and complementary crops), and government programmes.[1] Initially, a linear relationship between the dependent and independent variables was postulated. Thus:

$$A_t^* = \pi_0 + \pi_1 P_{t-1} + \pi_5 PF_{t-1} + \pi_6 PZ_{t-1} + \pi_7 DC_t + \mu_t \qquad 4.3$$

where the variables are as defined below.

2. Cotton growers adjust their actual acreage under cotton from year t-1 to year t in proportion to the discrepancy existing between the desired acreage A^* and the actual acreage A_{t-1} in the previous crop year.

Thus: $$A_t - A_{t-1} = \gamma(A_t^* - A_{t-1}) \qquad 4.4$$

where: $0<\gamma\leq 1$.

The above two postulates conform to the generalized Nerlovian adjustment process.[2] The estimating model is specified as follows:

$$A_t = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \gamma\pi_7 DC_t + \nu_t \qquad 4.5$$

where: A_t = area under cotton per 100 agricultural holdings in Ha.

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[1]The observed price is the price received by the cotton growers in the previous crop year.

[2]Equation 4.4 implies that the acreage planted (A_t) is adjusted in proportion to the difference between the desired acreage and the actual acreage in the previous year; that is, ($A_t^*-A_{t-1}$). This equation further implies that the planted acreage is a weighted average of the desired acreage (A_t^*) and the actual acreage (A_{t-1}), with weights γ and $1-\gamma$ respectively. The weights are derived as follows:

$$\begin{aligned} A_t - A_{t-1} &= \gamma(A_t^*-A_{t-1}),\ 0<\gamma\leq 1 \\ &= \gamma A_t^* - \gamma A_{t-1} \\ A_t &= \gamma A_t^* + A_{t-1} - \gamma A_{t-1} \\ &= \gamma A^* + (1-\gamma)A_{t-1} \end{aligned}$$

A_{t-1} = area under cotton per 100 agricultural holdings in year t-1 in Ha.

P_{t-1} = growers' price index (1965-66 = 100) lagged one year.

PF_{t-1} = lagged growers' price index (1965-66 = 100) for the selected staple food crop in the cotton zone.

PZ_{t-1} = lagged growers' price index (1965-66 = 100) for another selected crop in the cotton zone.

DC_t = dummy variable ($DC_t = 0$ or $DC_t = 1$) corresponding to the time of use of the Government Double Production Campaign.

π's = estimated parameters.

γ = coefficient of adjustment.

ν = random disturbance term ($\nu_t = \gamma U_t$).

A study by Schaller and Dean[1] suggests that the planted acreage of a crop is dependent on the observed price for the crop, the observed prices of the competitive and complementary crops, the acreage of the crop in the preceding year, and the total land resource available to the grower in a particular time period. These researchers also recommend the inclusion of any government programmes as determining variables.

The question of land available to a producer, especially under systems of lease and freehold tenure, sets a limit to any intended expansion he may plan.[2] Thus the acreage to be put under a crop in any one period must be associated with the total land resource at the disposal of

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[1]U. S. Department of Agriculture, "Predicting Regional Crop Production, An Application of Recursive Programming," *Technical Bulletin 1329* (Washington, D.C.: Economic Research and Services, 1965).

[2]Land tenure systems which prevailed in Uganda prior to 1975--before the Land Decree of 1975--were discussed in Chapter II.

producers. Incorporating this recommendation of Schaller and Dean into Models 4.3 and 4.4, gives a new estimating model with one additional variable.

$$A_t = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_4 M_t + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \nu_t \qquad 4.6$$

where: M_t = area under cultivation per 100 agricultural holdings in Ha, and the other variables are as defined previously on page 72.

Some agricultural economists[1] have argued that the introduction of statutory marketing boards led to a separation of world prices from the producers' prices. This implies a change in the structure of the planning behaviour of the producers involved in production of statutory-controlled commodities such that the producers may become unresponsive to the levels of, or changes in, world market prices. Olayide[2] derived output elasticities for Nigeria's main commodity exports with respect to world prices. The results indicated only modest responsiveness. His conclusion was that if the marketing boards' pricing policies could be modified to allow world market prices to influence producers, a more responsive reaction would be observed by producers.

The estimating model specified below is designed to test the cotton growers' responsiveness to world prices.

$$A_t = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + \gamma\pi_2 W_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_4 M_t + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \nu_t \qquad 4.7$$

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[1]Peter Ady, "Supply Functions in Tropical Agriculture," *Oxford Economics and Statistical Bulletin*, Vol. 30 (Oxford: May, 1968):157-188.

[2]S. A. Olayide, *Journal of Agricultural Economics*, Vol. xxiii, No. 3:263-275.

where: W_{t-1} = lagged export price index (1965-66 = 100) for cotton. The other variables are as previously defined on page 72.

Incorporating all the assumptions in Equations 4.3 and 4.4, a final estimating model of acreage response was specified as follows:

$$A_t = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + \gamma\pi_2 W_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_4 M_t + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \gamma\pi_7 DC_t + \nu_t \qquad 4.8$$

where all the variables are as previously defined.

The single equation acreage response Models 4.5 to 4.8 inclusive were fitted on a zone-by-zone basis to cotton time series data for the period from 1950 to 1974. Although a linear relationship between acreage and the explanatory variables was initially postulated, it is possible that a multiplicative or exponential relationship may apply. Thus Estimating Equations 4.5 to 4.8 inclusive were also tested in double-logarithmic and semi-logarithmic formulations. Except in the case of the double-logarithmic formulation, from which the policy variable (DC_t) was excluded, the previously outlined variables were retained in fitting these alternative functional forms.

The Yield Function

Since yield is an instrumental factor in supply analysis, a number of yield functions were fitted.

Yield levels may be changed purposively through improvements in biological sub-processes. The use of fertilizer and pesticide applications, the choice of plant varieties, and the general agronomic practices used, are the prime determinants of planned yields. Weather, on the other hand, is another factor influencing annual variations in crop yields. Changes in yields over time are expected to basically depend on

changes in technology and in weather conditions.

The influence of weather on crop yields may demonstrate both ran-com and non-random effects.[1] The non-random effects on yields may generate yield cycles if there is a series of years with good weather and high yields, followed by a series of years with bad weather and low yields.

Yield equations have taken three basic forms, namely: linear, double-logarithmic, and semi-logarithmic formulations. However, some limitations with respect to these formulations have been recognised by economists.[2] The use of linear functions in yield analysis may conceal changing technology in agricultural production over time. The criticism against the double-logarithmic formulation is based on the fact that if any of the variables included in the model are zero, then the dependent variable is zero--an inappropriate assumption with respect to crop yields. Semi-logarithmic formulations are recognised as tending to be more realistic in application than are double-logarithmic equations. In developed agriculture, semi-logarithmic functions have been used widely in analysing crop yields.[3] However, time series analysis of cotton data in Uganda tends to suggest the appropriateness of linear and double-logarithmic trends.[4]

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[1]Clifton B. Luttrell and R. Alton Gilbert, "Crop Yields: Random, Cyclic or Bunchy?" *American Journal of Agricultural Economics*, Vol. 58, No. 3 (August 1976):521-531.

[2]Earl O. Heady, *Economic Models and Quantitative Methods for Decisions and Planning in Agriculture*, pp. 269-272.

[3]J. L. Fulmer, "Relationship of the Cycle of Yields of Cotton and Apples to Solar and Sky Radiation," *Quarterly Journal of Economics*, No. 56 (1972):305-405.

[4]Planning Unit, Ministry of Agriculture and Forestry, *Crop Production Costs and Returns Analysis* (Entebbe: Research Section, 1975), pp.3-5.

As part of its objectives, this study investigated whether or not changes in weather conditions have had random effects on cotton yields in the Study Zones and also tested the form of yield function. The yield data are tested in linear, double-, and semi-logarithmic formulations.

Estimating Equations

1. The equations for testing randomness in yield data were specified as:

$$\log YE_t = \alpha_0 + \alpha_1 t + \mu_t \qquad 4.9$$

where: YE_t = yield of seed cotton per Ha in kilograms;

t = time variable ($t = 1, 2, \ldots, 25$; $1950 = 1$); and

α_i = estimated coefficients.

Two tests were applied to indicate the presence of randomness or cyclicity in the yield data. Firstly, the existence of first order positive serial correlation was tested for using the Durbin Watson statistic. Secondly, a test for skewness was applied.[1]

2. The yield functions were generally specified as:

$$YE_t = f(\overline{YE}_t, WE_t, t).$$

More specifically, in linear form:

$$YE_t = \beta_0 + \beta_1 \overline{YE}_t + \beta_2 WE_t + \beta_3 t + \mu_t \qquad 4.10$$

where: YE_t = yield of seed cotton per Ha in kilograms;

$\overline{YE}_t$ = trend variable, defined as a three-year moving average of cotton yields in kilograms per Ha (chosen following a trial of 2-, 3-, 4-, and 5-year moving averages).

WE_t = weather conditions (rainfall index, 1965-66 = 100);

t = time trend ($t = 1, 2, \ldots, 25$; $1950 = 1$); and

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[1] G. W. Snedecor and W. G. Cochrane, *Statistical Methods*, 6th ed. (Ames: Iowa State University Press, 1969), pp. 86-87.

β_i = parameters estimated.

Estimation Procedures

By the theory of multiple regression analysis, changes in one variable can be explained by reference to changes in several other variables. Such empirical association of variables is described by the classical linear regression model commonly presented in matrix notation as:

$$Y = XB + \varepsilon \qquad 4.11$$

The standard linear model assumes that:

> . . . the observed values taken by the dependent variable are realizations of an n-element random vector Y whose conditioned expectation given X is specified in [4.11]. X is an observed nXK matrix of rank K, consisting of values taken by K explanatory variables, while B is a column vector of K unknown parameters.[1]

In this study, the unknown parameters for the acreage and yield estimating functions oulined in the preceding sections of this chapter, were estimated through the use of the least squares method applied to the general linear model specified in Equation 4.11.[2] All the results are presented in Chapter V.

Estimation of Elasticities

There are generally three approaches used to estimate supply

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[1]Henri Theil, *Principles of Econometrics* (Santa Barbara, New York, London: Hamilton Publication, John Wiley and Sons, Inc., 1971),pp.101-118.

[2]The assumptions of the general linear model and its properties are fully outlined in:

J. Johnson, *Econometric Methods* (New York: McGraw-Hill Book Co., Inc., 1963), Chapter 5, pp.121-158;

Jan Kmenta, *Elements of Econometrics* (New York: Macmillan Publishing Co., Inc., 1971), Chapter 10, pp.347-405; and

Henri Theil, *Principles of Econometrics*, Chapter 3, pp.101-118.

elasticities:

1. the direct least squares approach;

2. separation of output into its components; that is, by the acreage and yield approach;[1] and

3. the production function approach.

Each of these approaches has its own limitations and is neither a complement to, nor a substitute for, another. By the limitations of data available for this study, the first approach was considered appropriate.

Elasticities were calculated at the mean values of the acreage $\overline{A}_t$ and the relevant price variables. The models are based on two major hypotheses. The first is that price expectations determine the desired or long-run level of acreage, A_t^*. The second hypothesis is that in each production period, acreage is adjusted in proportion to the difference between the desired or long-run acreage and the actual acreage in the preceding year, A_{t-1}.

Following Nerlove,[2] from Estimating Equations 4.5 to 4.8, both

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[1]Output is a product of acreage and yield. $Q = A \cdot Y$; if it is assumed that acreage planted and yields are functions of price (P), then totally differentiating the function, we obtain

$$\frac{\delta Q}{\delta P} = Y\frac{\delta A}{\delta P} + A\frac{\delta Y}{\delta P}.$$

Assuming that the input factors vary in proportion with acreage and that the function is homogeneous of degree one, we can express the elasticity of output in terms of acreage and yield.

$$\frac{\delta Q}{\delta P} \cdot \frac{P}{Q} = \frac{Q}{A} \cdot \frac{P}{Q}\frac{\delta A}{\delta P} + \frac{Q}{Y} \cdot \frac{P}{Q}\frac{\delta Y}{\delta P}$$

$\varepsilon_{qp} = \varepsilon_{ap} + \varepsilon_{yp}$, where: ε_{qp}, ε_{ap}, and ε_{yp} are the elasticities of output, acreage and yield respectively. Pan A. Yotopoulos and Jeffrey B. Nugent, *Economics of Development, Empirical Investigations*, pp.136-137.

[2]Marc Nerlove, *The Dynamics of Supply: Estimation of Farmers' Response to Price*, pp.59-61.

the short-run and long-run supply elasticities of acreage with respect to prices were estimated. The short-run elasticity, in this analysis, is taken as the response of acreage to price in one time period; that is, the period necessary to attain the proportion of acreage adjusted as measured by the coefficient of adjustment.

$$\varepsilon_{sr} = \frac{\gamma\pi\overline{P}_{t-1}}{\overline{A}_t} \qquad 4.12$$

where: ε_{sr} = short-run price elasticity;

$\overline{P}_{t-1}$ = the mean value of the price variable; and

$\overline{A}_t$ = the mean value of the acreage variable.

The long-run elasticity of acreage with respect to price is defined as the response over the time period necessary for complete adjustment. For the Models 4.5 to 4.8, $(1-\gamma) = 0$, so that $\gamma = 1$.

$$\varepsilon_{lr} = \frac{\gamma\pi\overline{P}_{t-1}}{\overline{A}_t} . \qquad 4.13$$

Thus: $$\varepsilon_{lr} = \frac{\pi\overline{P}_{t-1}}{\overline{A}_t} ; \qquad 4.14$$

where: $\overline{P}_{t-1}$ and $\overline{A}_t$ are as previously defined.

From Equations 4.12, 4.13 and 4.14, the short-run elasticity of acreage with respect to price is derived from the estimated regression coefficients for the own price variable and the long-run elasticity of acreage with respect to price is derived by dividing the short-run elasticity of supply by the coefficient of adjustment.

The estimated elasticities are presented in the following chapter. The remaining section of this chapter discusses the sources and the accuracy of the data which were used in the analysis.

The Data

Statistical data may impose limitations on econometric analyses in developing countries. Frequently econometricians are forced to use approximate data and proxy variables. Recorded time series data may have to be improved or adjusted before they are meaningful. Most of the data series for this study were transformed or modified before presentation. Some of the data may not relate directly to the original source.

Annual time series data for the period from 1950 to 1974 were used in the study. The major sources were:

1. Planning Unit, Ministry of Agriculture and Forestry, Entebbe, Uganda;

2. Statistics Division, Ministry of Planning and Economic Development, Entebbe, Uganda;

3. Statistical Office, Lint Marketing Board, Kampala, Uganda;

4. Uganda Government official published and unpublished reviews, reports, and statistical abstracts; and

5. United Nations publications.

Agricultural Holdings

In Uganda, settlement is generally dispersed; people live on family homesteads surrounded by their gardens and fields, which constitute agricultural holdings. The agricultural holdings, therefore, constitute the decision-making units for all farm activities in Uganda.

Data series on agricultural holdings in the study zones were compiled by the Planning Unit of the Uganda Ministry of Agriculture and Forestry. For incomplete data series, estimates were generated either by using interpolation techniques or by making projections assuming a growth

Table 4.2

NUMBER OF AGRICULTURAL HOLDINGS BY ZONE,
1950 - 1974 (000´)

Year	E.Buganda	Busoga	Teso	Lango	W.Nile	Bunyoro
1950	98.7	110.6	82.3	41.0	45.3	20.3
1951	100.9	110.9	82.6	41.7	46.9	23.1
1952	103.1	120.0	83.7	47.0	47.3	25.2
1953	105.4	127.3	85.2	57.0	48.1	26.9
1954	108.3	128.6	86.9	59.3	49.9	27.2
1955	113.2	129.3	87.0	62.1	50.1	28.3
1956	117.2	130.1	87.3	63.3	50.2	29.5
1957	118.3	135.2	89.4	65.2	50.9	30.1
1958	118.6	136.2	90.2	65.3	52.4	32.6
1959	119.9	137.1	96.3	67.9	52.9*	32.9
1960	123.6	136.9	98.3	68.3	52.9	33.1
1961	124.4	143.1	99.6	68.9	53.2	33.9
1962	125.3	145.3	99.9	69.2	53.5	34.2
1963	126.7	149.0	100.5	70.8	53.7	35.9
1964	126.9	152.5	101.3	71.2	54.1	36.7
1965	127.2	155.3	102.6	73.6	55.3	37.2
1966	130.4	156.7	105.2	73.9	56.2	42.6
1967	132.4	157.4	106.1	74.9*	56.9	42.9
1968	134.9	158.7	107.0	75.4	57.2	43.1
1969	135.2	162.5	107.2	80.2	60.3	43.9
1970	135.3*	164.7	107.8	83.6	66.9	44.2*
1971	135.4	171.3	107.9	84.7	68.2	44.7
1972	135.2	181.6	107.9	89.2	70.3	44.8
1973	135.3	186.9	108.2	94.0	72.4	45.9
1974	135.1	190.2	108.4	94.3	73.2	48.3

SOURCE: Uganda Ministry of Agriculture and Forestry, *Report of Annual Agricultural Statistics 1967/68 and 1968* (Entebbe: Visual Aids Centre, June 1969); Planning Unit, *Reports* (unpublished)(Entebbe: Statistics Section); Department of Agriculture, *Follow-up Report 1967/68* (Entebbe: Statistics, 1967).

*Interpolated.

Table 4.3

COTTON PRODUCTION BY ZONE, 1950 - 1974
(IN 000´ METRIC TONS)

Year	E.Buganda	Busoga	Teso	Lango	W.Nile	Bunyoro
1950	24.5	42.2	38.1	14.8	2.7	6.0
1951	24.6	36.9	34.3	12.4	3.0	6.0
1952	24.0	33.0	40.0	14.2	3.0	6.1
1953	21.9	39.2	45.2	14.6	3.3	6.1
1954	20.9	37.5	39.4	17.9	3.5	6.0
1955	21.5	36.2	39.1	18.5	3.7	6.1
1956	20.9	37.5	34.2	20.3	4.1	6.4
1957	21.2	45.1	33.8	20.5	4.2	6.7
1958	21.6	40.1	33.5	20.6	4.3	6.6
1959	21.5	39.2	34.3	20.6	4.3	6.7
1960	22.2	38.9	34.2	20.6	4.3	6.4
1961	23.1	43.3	33.1	18.8	5.5	6.1
1962	10.4	24.6	27.8	18.5	3.7	5.8
1963	13.1	51.3	35.8	19.8	7.1	5.8
1964	16.4	51.3	36.7	21.2	5.9	7.3
1965	11.6	61.9	32.3	22.5	7.0	8.2
1966	10.1	62.8	45.2	25.8	7.6	8.8
1967	9.4	53.5	36.5	23.1	7.9	11.5
1968	7.4	33.5	40.6	18.5	6.1	9.7
1969	6.1	48.6	47.9	21.3	7.0	12.4
1970	7.9	36.1	68.2	27.0	7.9	13.3
1971	6.7	49.1	54.5	18.5	6.4	10.9
1972	8.0	53.9	44.6	16.7	5.2	9.7
1973	7.3	49.1	35.8	20.6	7.9	6.0
1974	6.1	44.0	24.5	16.1	5.5	3.3

SOURCE: Planning Unit, Ministry of Agriculture and Forestry, "Reports" (Entebbe: Uganda-Statistics); Department of Agriculture, *Annual Agricultural Reports* (Entebbe: Department of Agriculture, Various Issues).

Table 4.4

AREA UNDER COTTON BY ZONE, 1950 - 1974
(IN 000´ Ha)

Year	E. Buganda	Busoga	Teso	Lango	W.Nile	Bunyoro
1950	117.6	122.7	136.2	58.7	18.9	17.3
1951	93.2	123.9	134.7	59.3	19.3	18.7
1952	77.6	121.7	126.3	60.2	19.2	19.3
1953	89.8	131.1	129.4	67.2	19.7	18.9
1954	96.7	117.6	118.7	63.3	20.1	19.7
1955	84.2	110.3	109.3	62.7	21.3	20.3
1956	75.6	131.9	121.3	63.9	21.4	22.3
1957	71.0	121.3	108.7	64.9	19.7	19.9
1958	78.8	97.4	108.3	64.7	19.4	19.9
1959	65.5	96.3	104.3	69.3	22.7	20.3
1960	51.0	97.4	108.5	65.3	21.9	20.1
1961	53.6	89.3	135.0	79.5	22.4	25.0
1962	52.7	90.2	128.8	70.1	23.3	22.6
1963	42.1	89.5	144.0	64.8	22.7	19.3
1964	49.4	87.7	89.2	68.7	25.0	15.2
1965	46.4	106.5	117.8	68.4	34.8	18.9
1966	38.2	101.2	155.5	80.5	33.8	18.7
1967	52.0	101.4	134.4	69.2	34.7	23.9
1968	44.4	109.9	148.8	83.4	41.4	27.6
1969	25.4	117.4	92.8	105.5	54.3	40.0
1970	26.7	87.0	86.0	105.9	66.9	37.6
1971	26.8	130.3	113.7	102.9	59.6	49.8
1972	17.6	138.2	81.2	104.8	60.9	57.1
1973	20.8	117.9	80.3	85.5	36.0	34.9
1974	21.3	95.1	66.1	55.1	21.9	14.6

SOURCE: Uganda Department of Agriculture, "Cotton Reports" (Entebbe: Department of Agriculture); Department of Agriculture, *Annual Agricultural Reports*, Various Issues (Entebbe: Agricultural Department).

Table 4.5

AVERAGE AREA UNDER CULTIVATION PER AGRICULTURAL HOLDING BY ZONE, 1950 - 1974 (IN HECTARES)

Year	E. Buganda	Busoga	Teso	Lango	W.Nile	Bunyoro
1950	1.500	1.668	2.884	2.517	1.302	1.345
1951	1.557	1.713	2.925	2.534	1.342	1.368
1952	1.574	1.725	2.931	2.548	1.368	1.511
1953	1.583	1.815	2.943	2.598	1.426	1.513
1954	1.565	1.925	2.952	2.612	1.444	1.528
1955	1.593	1.915	2.968	2.618	1.386	1.536
1956	1.596	1.925	2.982	2.684	1.518	1.562
1957	1.624	1.934	2.994	2.742	1.519	1.570
1958	1.612	1.952	2.994	2.750	1.517	1.570
1959	1.643	1.975	3.098	2.751	1.519	1.573
1960	1.675	1.943	3.159	2.754	1.588	1.574
1961	1.683	1.948	3.162	2.768	1.592	1.584
1962	1.678	1.947	3.168	2.769	1.592	1.613
1963	1.683	1.957	3.182	2.775	1.597	1.625
1964	1.697	2.002	3.214	2.818	1.602	1.683
1965	1.771	2.115	3.242	2.825	1.662	1.782
1966	1.783	2.118	3.314	2.915	1.682	1.715
1967	1.786	2.312	3.339	2.962	1.693	1.830
1968	1.793	2.228	3.362	2.973	1.695	1.790
1969	1.796	2.075	3.397	3.042	1.700	1.798
1970	1.846	2.343	3.398	3.120	1.712	1.813
1971	1.932	2.343	3.612	3.118	1.628	1.790
1972	2.001	2.413	3.483	3.254	1.732	1.815
1973	1.933	2.443	3.432	3.187	1.741	1.872
1974	2.132	2.454	3.458	3.112	1.821	1.930

SOURCE: Uganda Department of Agriculture, *Form One Reports*, Various Issues (Entebbe: Department of Agriculture); Uganda Government, *Uganda Census of Agriculture* (Entebbe: Government Printer, 1965).

rate of 1.25 percent per year in the number of agricultural holdings;[1] thus complete accuracy of information on holdings may not be guaranteed. Data on holdings are presented in Table 4.2.

Data on the area under cultivation and the area and production of cotton (see Tables 4.3 and 4.4) for all Study Zones were computed on the basis of averages per agricultural holding, by taking the annual aggregate of those data divided by the corresponding annual number of agricultural holdings. This adjustment was made so that the data series would reflect the decision-making units of farm activities. Tables 4.5 and 4.6 summarise the derived data series on the area under cultivation and the area and production of cotton per agricultural holding respectively. Table 4.7 shows the relative contribution of each Study Zone to the overall cotton production in Uganda.

Information on cotton and food crop prices is summarised in Table 4.8. Prices were converted to indices based on an average of 1965 and 1966 defined equal to 100. The price indices were then deflated by the cost of living index for low income people in Kampala City.[2] Table 4.9 shows the price indices for the staple and other food crops which were used in this study. All price indices were calculated on an annual basis. Tables 4.10 and 4.11 present the yield data and Table 4.12 shows

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[1]As indicated by * in Table 4.2. Uganda Department of Agriculture, *Report on Annual Agricultural Statistics 1967/68 and 1968* (Entebbe: Visual Aids Centre, June 1969), pp. 8-9.

[2]In time series analysis of supply or acreage response, inflationary processes should be adequately allowed for. In this study, because of lack of an appropriate deflating index such as the Index of prices paid by farmers, the Cost of Living Index for low income people in Kampala was used to deflate the price data.

Table 4.6

ESTIMATED AREA AND PRODUCTION OF COTTON PER AGRICULTURAL HOLDING
1950 - 1974

Year	Area Under Cotton Per Agricultural Holding (in hectares)							Average Cotton Production Per Agricultural Holding (in kilograms)						
	Uganda	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro	Uganda	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro
1950	0.93	1.18	1.11	1.55	1.46	0.56	0.95	210	249	382	475	324	62	295
1951	0.83	0.93	1.12	1.53	1.45	0.55	0.91	229	244	333	415	303	74	258
1952	0.81	0.75	1.01	1.51	1.29	0.52	0.76	219	233	275	478	285	68	242
1953	0.82	0.85	1.03	1.52	1.18	0.48	0.70	232	208	308	531	250	67	228
1954	0.83	0.88	0.91	1.36	1.05	0.45	0.68	153	193	292	453	245	65	221
1955	0.78	0.74	0.95	1.25	1.10	0.49	0.72	207	190	280	449	284	70	216
1956	0.64	0.65	1.01	1.38	1.15	0.50	0.76	201	178	288	392	310	86	210
1957	0.68	0.60	0.89	1.24	0.99	0.46	0.72	135	179	334	378	252	83	222
1958	0.79	0.65	0.72	1.20	1.11	0.48	0.74	203	182	294	371	309	85	202
1959	0.64	0.55	0.70	1.10	1.12	0.49	0.78	176	179	286	356	312	87	203
1960	0.52	0.41	0.71	1.37	0.97	0.44	0.61	166	180	284	348	262	81	193
1961	0.69	0.43	0.62	1.28	0.98	0.45	0.52	164	185	303	332	265	82	180
1962	0.59	0.42	0.62	1.43	1.10	0.47	0.70	94	83	169	278	270	103	169
1963	0.64	0.33	0.60	0.98	1.08	0.42	0.68	151	103	344	356	280	106	169
1964	0.67	0.39	0.58	1.15	1.05	0.41	0.67	170	128	336	362	275	69	167
1965	0.69	0.35	0.60	1.48	0.93	0.40	0.64	184	91	334	314	273	68	222
1966	0.68	0.29	0.55	1.25	0.84	0.38	0.64	188	77	337	430	272	67	236
1967	0.64	0.38	0.54	1.39	0.86	0.48	0.69	183	71	340	344	314	132	270
1968	0.61	0.32	0.59	1.28	0.81	0.39	0.43	142	55	211	377	245	108	226
1969	0.61	0.20	0.72	0.96	0.85	0.43	0.45	153	45	299	447	250	127	193
1970	0.62	0.20	0.53	0.80	0.82	0.40	0.42	180	58	219	633	248	130	244
1971	0.72	0.20	0.75	1.05	0.81	0.43	0.81	154	50	287	505	320	139	203
1972	0.47	0.13	0.75	0.75	0.80	0.35	0.64	146	59	297	413	215	116	186
1973	0.35	0.15	0.53	0.74	0.83	0.38	0.66	144	54	263	331	220	118	131
1974	0.24	0.16	0.50	0.51	0.69	0.35	0.31	99	45	231	226	217	119	68

SOURCE: Department of Agriculture, *Annual Cotton Reports* (Entebbe: Agricultural Department); Planning Unit, *Reviews, Project Appraisals* (Entebbe: Planning Unit, Various Issues); Uganda Government, *Uganda Census of Agriculture* (Entebbe: Government Printer, 1965).

Table 4.7

RELATIVE CONTRIBUTION TO OVERALL COTTON PRODUCTION BY ZONE, 1950 - 1974

Year	Percentage Contribution						
	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro	Other Zones
1950	12.7	21.7	20.1	7.7	1.4	3.1	33.3
1951	11.6	17.3	15.1	5.8	1.4	2.9	45.9
1952	11.5	16.0	19.2	5.9	1.3	3.0	43.1
1953	9.8	17.6	20.2	7.2	1.4	2.7	41.1
1954	13.2	23.5	24.7	11.2	2.1	3.7	21.6
1955	10.3	17.6	19.1	9.0	1.8	2.9	39.3
1956	9.8	17.9	16.3	9.7	2.0	3.0	41.3
1957	14.2	30.2	22.6	13.7	2.8	4.5	12.0
1958	9.6	17.9	14.9	9.2	1.9	2.9	43.7
1959	10.6	19.4	17.0	10.2	2.1	3.3	37.4
1960	11.5	20.1	17.7	10.6	2.2	3.3	34.6
1961	11.6	20.7	16.6	9.4	2.7	3.1	34.9
1962	10.0	23.8	26.8	17.9	3.6	5.6	12.3
1963	5.4	25.2	17.6	9.7	3.4	2.9	35.8
1964	7.5	23.4	16.7	9.6	2.7	3.3	36.8
1965	4.9	25.8	13.5	9.4	2.9	3.4	40.1
1966	4.0	25.2	18.2	10.4	3.1	3.5	35.6
1967	3.6	20.6	21.7	8.9	3.0	4.4	37.8
1968	3.9	17.3	21.0	9.6	3.1	5.0	40.1
1969	2.7	21.3	21.0	9.3	3.1	5.4	37.2
1970	3.1	14.1	26.6	10.5	3.1	5.2	37.4
1971	3.6	21.7	24.1	8.2	2.8	4.8	34.8
1972	3.2	24.1	20.0	7.4	2.3	4.3	38.7
1973	3.2	21.8	15.9	9.1	3.5	2.6	43.9
1974	3.6	26.5	14.7	9.7	3.3	2.0	40.2

SOURCE: Uganda Department of Agriculture, "Cotton Reports" (unpublished)(Entebbe: Department of Agriculture); *Annual Department Reports* (Entebbe: Department of Agriculture, Various Issues); Lint Marketing Board, *Cotton Reports* (Kampala: Statistics Section, Various Issues).

Table 4.8

PRICES AND PRICE INDICES FOR MAJOR CASH AND FOOD CROPS
1950 - 1974

Year	Price Paid to the Growers (in Ug. Cents per kgm)								Price Indices (1965-1966 = 100)				
	Cotton (Safi)	Coffee Robusta	Coffee Arabica	Plantains	Maize	Finger Millet	Sweet Potatoes	Ground Nuts	Cotton (Safi)	Coffee Arabica	Coffee Robusta	Food Crops (Rural)	Food Crops (Towns)
1950	112	110	110	06	08	06	06	46	171	132	233	64	130
1951	112	154	110	08	03	12	08	48	168	130	321	77	135
1952	113	154	154	16	05	12	06	50	160	171	304	94	158
1953	114	154	215	14	16	12	18	52	148	225	283	113	154
1954	115	224	225	16	20	22	20	52	152	222	390	119	164
1955	136	280	198	12	22	32	22	53	160	183	459	116	158
1956	123	168	231	20	24	40	26	58	137	200	261	113	152
1957	125	179	231	22	26	40	26	36	139	202	278	127	158
1958	130	179	163	22	30	36	28	55	145	143	278	128	163
1959	105	152	163	26	20	42	26	55	115	140	231	129	173
1960	107	125	163	22	26	48	32	62	117	140	190	131	201
1961	123	112	163	30	22	50	34	67	130	135	165	133	195
1962	128	123	163	34	36	36	40	65	128	127	169	126	188
1963	128	107	163	38	40	46	42	95	121	118	137	117	191
1964	114	128	163	40	42	50	48	125	96	108	151	107	178
1965	125	96	163	42	40	56	56	128	90	92	96	94	156
1966	132	88	163	56	27	68	52	135	108	105	100	109	187
1967	88	88	154	52	29	72	58	175	67	93	95	109	188
1968	99	88	154	56	32	88	54	175	74	91	93	122	188
1969	110	106	134	52	35	96	54	190	72	68	96	116	196
1970	120	119	134	122	60	182	92	225	76	67	105	160	218
1971	125	119	134	86	74	192	88	375	69	58	92	160	211
1972	125	119	134	92	88	202	90	415	72	60	93	178	250
1973	130	119	134	68	79	192	123	450	70	57	89	191	243
1974	165	125	136	172	122	342	162	450	82	53	86	208	238

SOURCE: Uganda Department of Agriculture, *Agricultural Annual Reports* (Entebbe: Agricultural Department, Various Issues); Uganda Government, *Statistical Abstracts* (Entebbe: Government Printer, Various Issues).

Table 4.9

PRICE INDICES FOR THE MAJOR FOOD CROPS BY ZONE, 1950 - 1974
(1965-66 = 100)

Year	East Buganda		Busoga		Teso		Lango		West Nile		Bunyoro	
	Plantains	Sweet Potatoes	Plantains	Ground Nuts	Ground Nuts	Finger Millet	Ground Nuts	Finger Millet	Cassava	Finger Millet	Ground Nuts	Finger Millet
1950	21	33	16	85	82	52	64	44	32	42	85	32
1951	30	30	20	109	105	44	82	36	38	38	90	34
1952	50	37	21	107	103	42	80	35	35	40	102	36
1953	45	40	20	133	129	48	100	40	39	43	119	41
1954	43	46	22	128	128	52	95	43	46	42	120	43
1955	42	43	29	84	83	34	63	29	42	30	123	38
1956	39	58	35	111	99	42	83	35	44	34	110	40
1957	52	68	43	109	105	66	82	55	48	60	104	56
1958	61	74	44	62	53	77	40	64	55	64	103	63
1959	66	54	41	70	68	96	53	79	62	70	56	79
1960	69	64	36	89	86	110	67	83	69	82	96	86
1961	75	78	37	81	78	73	61	61	86	59	93	81
1962	78	87	47	87	84	105	65	88	59	90	88	89
1963	97	95	50	104	101	106	78	88	57	92	120	90
1964	100	102	55	109	106	131	82	108	71	110	126	113
1965	110	116	59	118	114	116	88	96	67	98	143	104
1966	125	129	65	116	120	121	99	99	81	99	144	109
1967	144	166	71	183	170	159	132	132	149	140	162	130
1968	151	185	101	185	172	161	172	133	156	152	172	134
1969	158	154	95	187	211	223	184	174	171	180	193	187
1970	198	267	138	288	212	254	185	210	176	224	212	215
1971	172	266	163	273	252	226	126	187	176	232	252	239
1972	190	284	189	339	323	268	163	221	202	245	249	212
1973	252	292	206	433	335	271	252	224	248	260	293	253
1974	241	312	189	469	267	262	203	216	250	292	369	274

SOURCE: Planning Unit, "Reports" (unpublished) (Entebbe: Statistics Section); Uganda Government, *Statistical Abstract* (Entebbe: Government Printer, Various Issues).

Table 4.10

YIELD OF SEED COTTON PER HECTARE,
1950 - 1974 (KILOGRAMS)

Year	E.Buganda	Busoga	Teso	Lango	W.Nile	Bunyoro
1950	209	342	297	253	149	345
1951	264	297	294	210	155	322
1952	309	271	317	235	158	312
1953	243	300	349	239	157	319
1954	216	319	332	293	172	307
1955	256	330	357	295	173	300
1956	277	294	293	319	193	299
1957	299	372	310	315	215	336
1958	274	411	309	318	220	334
1959	328	406	330	296	199	330
1960	435	399	315	236	195	319
1961	431	485	244	254	244	242
1962	199	293	216	305	157	256
1963	310	573	250	310	310	299
1964	332	585	410	329	235	491
1965	249	581	274	320	200	435
1966	264	518	290	330	225	472
1967	181	496	420	223	229	491
1968	166	294	273	210	147	352
1969	240	414	516	215	130	310
1970	296	414	536	113	119	354
1971	251	375	478	109	106	220
1972	453	390	549	253	95	160
1973	352	415	446	247	215	156
1974	286	453	371	293	251	226

SOURCE: Planning Unit, "Statistical Reports" (unpublished) (Entebbe: Statistics); Department of Agriculture, *Cotton Reports* (Entebbe: Department of Agriculture, Various Issues); Uganda Government, *Uganda Census of Agriculture* (Entebbe: Government Printer, 1966).

Table 4.11

YIELDS OF SEED COTTON (3-YEAR MOVING AVERAGE)
BY ZONE, 1950 - 1974 (IN KILOGRAMS)

Year	E.Buganda	Busoga	Teso	Lango	W.Nile	Bunyoro
1950	--	--	--	--	--	--
1951	261	303	303	233	154	326
1952	272	306	320	228	157	318
1953	256	313	333	256	162	313
1954	238	333	346	276	267	309
1955	250	331	327	302	179	267
1956	277	349	320	310	194	278
1957	283	376	340	318	209	289
1958	300	413	316	310	212	300
1959	346	422	318	309	215	294
1960	398	447	296	281	223	264
1961	355	409	258	281	232	239
1962	313	460	237	267	237	232
1963	280	495	292	264	244	315
1964	297	568	311	289	248	360
1965	248	510	325	280	220	418
1966	198	478	328	285	218	418
1967	170	422	328	292	200	391
1968	162	378	403	256	135	337
1969	201	347	442	220	98	291
1970	229	397	510	181	85	247
1971	300	376	521	145	73	197
1972	319	376	491	111	105	164
1973	331	402	455	103	120	167
1974	--	--	--	--	--	--

SOURCE: Derived from Table 4.10.

Table 4.12

RAINFALL DISTRIBUTION BY ZONE
(INDICES 1965-66 = 100)
1950 - 1974

Year	E.Buganda	Busoga	Teso	Lango	W.Nile	Bunyoro
1950	98.0	87.0	94.7	99.0	98.6	99.5
1951	97.0	86.6	95.3	101.2	98.5	108.1
1952	97.2	86.0	94.5	100.4	98.4	108.3
1953	97.1	85.0	94.5	100.4	98.4	108.6
1954	97.0	91.0	94.0	94.1	99.0	108.1
1955	93.6	91.1	94.0	94.1	99.0	108.1
1956	95.2	86.9	94.4	87.8	100.0	107.5
1957	96.3	84.0	97.8	94.1	100.3	96.8
1958	95.3	86.4	97.7	94.2	107.4	89.1
1959	94.9	87.6	97.7	94.4	107.0	96.9
1960	95.2	93.9	98.0	94.6	107.3	97.0
1961	97.0	95.9	98.9	95.2	108.3	98.4
1962	95.7	95.9	99.1	95.2	105.1	98.8
1963	97.4	99.2	99.1	95.2	105.1	99.0
1964	99.9	98.7	96.5	96.1	104.6	99.7
1965	100.0	99.7	99.7	103.9	101.0	100.0
1966	100.3	100.1	100.2	96.1	98.9	100.0
1967	104.4	100.3	100.1	96.3	96.7	100.0
1968	93.1	100.4	100.4	102.7	94.9	98.9
1969	96.1	100.2	100.4	96.0	94.9	99.2
1970	114.1	99.4	100.4	95.8	93.6	99.6
1971	112.0	99.4	100.2	95.6	92.3	99.1
1972	110.3	122.7	115.5	102.1	87.4	131.1
1973	114.0	99.3	100.1	103.7	91.9	98.8
1974	111.0	99.3	101.0	101.6	92.0	98.7

SOURCE: Uganda Department of Agriculture, *Annual Agricultural Reports* (Entebbe: Department of Agriculture, Various Issues).

the rainfall data which were used to estimate the cotton yield functions.

Summary and Conclusion

This chapter has briefly summarised the results of some studies on the supply relationships in smallholder peasant agriculture. The chapter has developed and presented models which are used in this study to estimate cotton acreage response and yield functions for the Study Zones. The data required for this analysis are also presented in this chapter.

Generally, supply models are intended to be prescriptive in nature by throwing some light upon the consequences of changes in the variables involved in the model construction. Specification of the model structure and estimation of parameters provides a basis for prescriptive analysis of supply response. The chapter which follows presents estimates of suppliers' reaction to factors which influence cotton acreage and hence supplies.

CHAPTER V

ANALYTICAL RESULTS

Introduction

The preceding chapter outlined the analytical techniques which were used to estimate the unknown parameters π_i, γ_i, and β_i of the acreage response and yield functions. These parameters were generated through the use of the least squares method of regression analysis.

In econometric analysis, where *a priori* reasoning suggests that the variation in a dependent variable is partly or wholly explained by its own lagged value, Ordinary Least Squares (OLS) estimates tend to be biased.[1] However, Christ,[2] Griliches,[3] Nerlove,[4] and Theil[5] have shown that under conditions where the sample size is sufficiently large and the

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[1]In the usual regression model, the regressor is assumed to be a mathematical variable and fixed in repeated sampling. The independent variable is therefore uncorrelated with the disturbance term. However, in the Nerlovian partial adjustment model used in this analysis, the regressor A_{t-1} cannot be considered a truly mathematical variable. According to this specification of the Model, A_t is dependent on A_{t-1} and $V\hat{t}$.

[2]C. Christ, *Econometric Models and Methods* (New York: John Wiley and Sons, 1966), pp. 374-379.

[3]Z. Griliches, "Distributed Lags: A Survey," *Econometrica*, Vol. 35, No. 1 (January 1967).

[4]Marc Nerlove, "Estimated Elasticities of Supply of Selected Agricultural Commodities," *Readings in Economics of Agriculture*, pp. 67-77.

[5]Henri Theil, *Principles of Econometrics*, pp. 408-415.

model is an autoregressive linear regression, the Ordinary Least Squares estimates may be consistent and unbiased.

This study used the Nerlovian partial adjustment model. The advantage of this model is that if the estimated residuals V_t' of the Estimating Equations 4.5, 4.6, 4.7 and 4.8 are found to be serially uncorrelated, then (since $V_t' = \gamma\mu_t$) the random disturbances μ_t are also serially uncorrelated.[1] Thus the estimated coefficients generated under the adjustment hypothesis--particularly when the number of observations covered by the study is sufficiently large--are not likely to be seriously affected by serial correlation.

The choice of the variables in both the acreage response and yield functions was based on the theory of supply and on *a priori* knowledge of the principal constraints which affect cotton production in the study areas. The variables "land under cultivation" and the "world cotton price," were successively added to Estimating Equation 4.5 to form Estimating Equations 4.6 and 4.7 respectively. Estimating Equation 4.8 featured all the hypothesised variables. Both the acreage response and yield functions were tested in double and semi-logarithmic formulations.

In comparing different model formulations, the estimated acreage and yield functions were judged on the basis of the following criteria:

1. whether the estimates contradict economic theory as to the signs taken by the regression coefficients;

2. whether the regression coefficients are statistically

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[1]Raj Krishna, "Farm Supply Response in India-Pakistan: A Case Study of the Punjab Region," in *Readings in Economics of Agriculture*, pp.78-88.

significant as measured by the students' t-test;

3. whether the coefficients of multiple determination indicate a reasonable fit to the data and are significant as measured by the F-test;

4. whether residuals show no serial correlation; and

5. whether there is an absence of severe multicollinearity.[1]

The related estimates of the short- and long-run supply elasticities and coefficients of adjustment were calculated and are presented in this chapter in which the consistency, realism, and validity of the estimated acreage response functions are also discussed.

Results of the Acreage Response Models: Linear Formulations of Models from 4.5 to 4.8

As with the other formulations of the acreage response models, these linear formulations were fitted to annual data covering the period from 1950 to 1974. Model 4.5 expresses the average acreage under cotton per 100 agricultural holdings as a function of the observed cotton price paid to growers (index 1965-66 = 100 and lagged one year), cotton acreage lagged one year, the observed prices of staple and other food crops (index 1965-66 = 100 and lagged one year), and a government policy

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[1]Klein suggests that multicollinearity is severe if $r_{ij} > R_y$, where: r_{ij} is the zero-order correlation between the independent variables X_i and X_j ($i \neq j$), and R_y is the multiple correlation coefficient between the dependent variable Y and the set of independent variables X in the multiple regression model. L. R. Klein, *An Introduction to Econometrics* (Englewood Cliffs, New Jersey: Prentice-Hall Co., 1962, pp. 64, 101, 102. Note: this feature and other data problems are discussed later in this chapter.

variable.[1] The government policy variable was entered into the supply response model as a dummy variable.

The results of Model 4.5 for the various cotton zones are presented in Table 5.1. The amount of variation explained by the four variables included in this model was approximately 94, 82, 72, 92, 86 and 57 percent for East Buganda, Busoga, Teso, Lango, West Nile and Bunyoro, in that order. The application of the F-test to the estimated equations indicated that the relationship postulated for the various zones was significant at the 0.05 level of significance. The estimated equations indicated no evidence of serial correlation as shown by the Durbin Watson statistic.

The estimated coefficients of the cotton price variable were all positive and were all, except for Busoga and Teso, significantly different from zero at the 0.05 level of significance. In this linear model formulation, the price variable alone accounted for 45 to 52 percent of the 57 to 94 percent of the explained variation in the estimated equations for the six cotton zones. The estimated coefficient on the policy variable (DC_t), suggests a negative relationship with the dependent variable, cotton acreage. The signs of the estimated coefficients for the prices of staple food crops in Bosoga and Teso were negative, while the signs of similar coefficients in other zones were positive. Except for Busoga zone, the signs of the estimated coefficients for the prices of

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[1]The government policy variable is the Double Production Programme. Although the inclusion of the variable did not provide conclusive results in this analysis, its contribution to the overall cotton production was judged on the basis of the sign taken by the estimated coefficient of the dummy variable (DC_t).

Table 5.1

ESTIMATED ACREAGE RESPONSE FUNCTIONS MODEL 4.5

$$A_t = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \gamma\pi_7 DC_t + \nu_t'$$

Cotton Zone	Estimated Coefficients[a]						R^2	DW[b]
	Intercept	P_{t-1}	A_{t-1}	PF_{t-1}	PZ_{t-1}	DC_t		
East Buganda	-19.06498	0.2711** (0.1253)	0.5903*** (0.1261)	0.1122 (0.1144)	-0.0627 (0.0795)	-0.1548 (7.2921)	0.9358	1.811†
Busoga	-1.83022	0.1558 (0.1221)	0.6350*** (0.1731)	-0.1557 (0.1459)	0.2259* (0.1514)	-17.2338** (9.9894	0.8165	2.340†
Teso	116.05304	0.0264 (0.2547)	0.2018 (0.2559)	-0.1153 (0.1967)	-0.0631 (0.1309)	-19.5170 (19.2738)	0.7241	1.992†
Lango	12.17456	0.4248*** (0.1113)	0.3210*** (0.1221)	0.1319** (0.0692)	-0.0696* (0.0431)	-6.0769 (5.4699)	0.9166	1.761†
West Nile	21.62896	0.1840*** (0.0368)	0.0596 (0.1419)	0.0546** (0.0283)	-0.0021 (0.0296)	-7.1577*** (2.4224)	0.8605	1.500††
Bunyoro	-6.76475	0.4642*** (0.1586)	0.1068 (0.2976)	0.1992* (0.1219)	-0.0603 (0.1056)	-10.4608 (16.1265)	0.5675	1.894†

[a]Standard errors are in parentheses.
[b]Durbin Watson Statistic (0.01 level).
***Coefficients are significant at 0.01 level.
**Coefficients are significant at 0.05 level.
*Coefficients are significant at 0.10 level.
†The hypothesis of no serial correlation is accepted.
††Tests for serial correlation are inconclusive.

other selected food crops were negative.

The analysis of Model 4.6 was done to judge the possible influence which changes in the available land under cultivation might have on cotton acreage. In addition to the variable "land under cultivation," the model includes the "price paid to growers for cotton lagged one year," and the "prices of staple and other selected food crops lagged one year," as explanatory variables. The price variables are expressed as indices, with 1965-66 = 100. The parameters were estimated by fitting Estimating Equation 4.6 to annual data series from 1950 to 1974. The results are presented in Table 5.2.

For all zones except Teso, the estimated coefficients of the variable "land under cultivation" indicated a negative relationship with cotton acreage. However, the estimated coefficients of this variable were significant at the 0.10 level of significance for only three zones --East Buganda, Lango, and West Nile. The inclusion of this variable in this model did not appear to have appreciably improved the usefulness of the various estimated response functions.

Model 4.7 was designed to test the effect of changes of the world cotton price on cotton acreage. This model expresses the area under cotton as a function of all the variables specified in Model 4.6 plus the variable of "world cotton price." The results of this model are presented in Table 5.3.

The estimated coefficients of the variable "world cotton price index" were all positive but only in the case of the West Nile and Bunyoro acreage response functions were these estimates significant at the 0.10 level of significance. The inclusion of the world cotton price as one of

Table 5.2

ESTIMATED ACREAGE RESPONSE FUNCTIONS MODEL 4.6

$$A_t = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_4 M_t + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \nu_t'$$

Cotton Zone	Estimated Coefficients[a]						R^2	DW[b]
	Intercept	P_{t-1}	A_{t-1}	M_t	PF_{t-1}	PZ_{t-1}		
East Buganda	77.18239	0.2996*** (0.1136)	0.5685*** (0.1203)	-0.6261** (0.3335)	0.2161** (0.1294)	-0.0362 (0.0664)	0.9425	1.803†
Busoga	48.82204	0.1009 (0.1506)	0.5697*** (0.1875)	-0.1743 (0.2524)	-0.1400 (0.1575)	0.1740* (0.1581)	0.7917	1.915†
Teso	-25.27385	0.1042 (0.3262)	0.2340 (0.2582)	0.4465 (0.7720)	-0.2081 (0.2660)	-0.1042 (0.1271)	0.7137	2.163†
Lango	107.97697	0.3689*** (0.1018)	0.2320* (0.1435)	-0.2987* (0.1961)	0.1499** (0.0685)	-0.0444 (0.0442)	0.9210	1.638†
West Nile	82.50064	0.0672* (0.0484)	0.1938* (0.1601)	-0.2335** (0.1235)	0.0585** (0.0319)	-0.0541** (0.0296)	0.8272	1.667†
Bunyoro	56.48714	0.3847** (0.1965)	0.0538 (0.2218)	-0.2317 (0.4522)	0.1681* (0.1140)	-0.0788 (0.0962)	0.5638	1.768†

[a] Standard errors are in parentheses.

[b] Durbin Watson Statistic (0.01 level).

***Coefficients are significant at 0.01 level.

**Coefficients are significant at 0.05 level.

*Coefficients are significant at 0.10 level.

†The hypothesis of no serial correlation is accepted.

Table 5.3

ESTIMATED ACREAGE RESPONSE FUNCTIONS MODEL 4.7

$$A_t = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + \gamma\pi_2 W_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_4 M_t + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \nu_t'$$

Cotton Zone	Estimated Regression Coefficients[a]							R^2	DW[b]
	Intercept	P_{t-1}	W_{t-1}	A_{t-1}	M_t	PF_{t-1}	PZ_{t-1}		
East Buganda	77.15834	0.2354** (0.1249)	0.0635 (0.0897)	0.5551*** (0.1235)	-0.6222** (0.3279)	0.1989* (0.1336)	-0.0405 (0.0676)	0.9441	1.906†
Busoga	41.55377	0.0990 (0.1547)	0.0517 (0.1758)	0.5456*** (0.2092)	-0.1474 (0.2748)	-0.1653 (0.1831)	0.1899 (0.1710)	0.7928	1.907†
Teso	-137.38572	0.1390 (0.3206)	0.0194 (0.0846)	0.2041 (0.2534)	0.8175* (0.6200)	-0.3851** (0.1540)	-0.0043 (0.1436)	0.7031	2.154††
Lango	105.98658	0.3746*** (0.1075)	0.0032 (0.0483)	0.2436* (0.1563)	-0.2932* (0.2030)	0.1502 (0.0704)	-0.0399 (0.0496)	0.9213	1.669††
West Nile	83.88088	0.0839* (0.0511)	0.0352* (0.0249)	0.1712 (0.1814)	-0.2461** (0.1240)	0.0666** (0.0329)	-0.0505* (0.0298)	0.8369	1.710††
Bunyoro	48.44645	0.4617** (0.2042)	0.1665* (0.1178)	0.0117 (0.2218)	-0.1833 (0.4480)	0.1661 (0.1126)	-0.0392 (0.1005)	0.5982	1.858†

[a]Standard errors are in parentheses.
[b]Durbin Watson statistic.
***Coefficients are significant at 0.01 level.
**Coefficients are significant at 0.05 level.
*Coefficients are significant at 0.10 level.
†The hypothesis of no serial correlation is accepted.
††Tests for serial correlation are inconclusive.

the explanatory variables in Estimating Equation 4.7 appears, in the case of Busoga, Teso and Bunyoro, to have reduced the explained variation of the estimated acreage response functions by some 2 to 4 percent. However, the application of the F-test indicated that the coefficients of determination of the estimated acreage response functions for all zones were significant at the 0.05 level of significance. The application of the Durbin Watson test to this set of estimated acreage response functions provided inconclusive evidence of autocorrelation for Lango, West Nile, and Teso. The estimated coefficients for all other explanatory variables included in this model retained the signs which applied in the estimation of Models 4.5 and 4.6.

Table 5.4 presents the results of Estimating Equation 4.8, which features all the variables hypothesised to explain acreage response. Model 4.8 expresses the average area under cotton per 100 agricultural holdings as a function of all the variables specified in Models 4.5, 4.6, and 4.7. This model was designed to test the influence of changes in all the variables outlined in the above models on the area that is committed to cotton in any one season.

The signs taken by the estimated regression coefficients for all variables which were included in the model were consistent between models for all zones. The variables "cotton price index" and "world cotton price index" maintained their positive association with the dependent variable of cotton acreage. The estimated coefficients on the explanatory variable of the lagged dependent variable with this model, for all zones, were positive. However, only in the case of East Buganda, Busoga, and Teso were these estimated coefficients significant at the 0.10 level

Table 5.4

ESTIMATED ACREAGE RESPONSE FUNCTIONS

MODEL 4.8: $A_t = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + \gamma\pi_2 W_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_4 M_t + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \gamma\pi_7 DC_t + v_t'$

Cotton Zone	Estimated Regression Coefficients[a]								R^2	DW[b]
	Intercept	P_{t-1}	W_{t-1}	A_{t-1}	M_t	PF_{t-1}	PZ_{t-1}	DC_t		
East Buganda	136.98628	0.2073*	0.0353	0.5524***	-0.9609*	0.2774**	-0.0741	-8.6530	0.9469	1.879††
		(0.1293)	(0.0953)	(0.1241)	(0.5771)	(0.1555)	(0.0773)	(9.4833)		
Busoga	20.74572	0.1162	0.0540	0.5883***	-0.0968	-0.1696	0.2408*	-16.6020*	0.8205	2.209†
		(0.1488)	(0.1687)	(0.2025)	(0.2656)	(0.1757)	(0.1673)	(10.5647)		
Teso	-34.98283	0.1357	0.0032	0.1904	0.4565	-0.2380	-0.0046	-20.7502	0.7275	1.997†
		(0.3516)	(0.0148)	(0.2496)	(0.6729)	(0.1906)	(0.0158)	(16.3140)		
Lango	-94.14899	0.3855***	0.0043	0.2480*	-0.2595	0.1548**	-0.0453	-1.6599	0.9215	1.706††
		(0.1214)	(0.1413)	(0.1621)	(0.2591)	(0.0754)	(0.0568)	(7.5478)		
West Nile	52.91991	0.1484***	0.0207	0.1313	-0.1364	0.0638**	-0.0142	-5.7202**	0.8716	1.565††
		(0.0561)	(0.0326)	(0.1670)	(0.1251)	(0.0301)	(0.0324)	(2.7514)		
Bunyoro	25.98195	0.4868**	0.1666*	0.1160	-0.1595	0.1932*	-0.0072	-9.7271	0.6069	2.015†
		(0.2125)	(0.1405)	(0.3123)	(0.4593)	(0.1236)	(0.1158)	(16.3995)		

[a]Standard errors are in parentheses.

[b]Durbin Watson statistic (test at 0.01 level).

***Coefficients are significant at 0.01 level.

**Coefficients are significant at 0.05 level.

*Coefficients are significant at 0.10 level.

†The hypothesis of no serial correlation is accepted.

††Tests for serial correlation are inconclusive.

of significance. Except for the Teso cotton zone, the variable "land under cultivation" was negatively associated with cotton acreage. The estimated coefficients of the dummy variable were all negative; however, these estimates were not significantly different from zero in a number of cases.

The overall variation explained by this particular model for the various cotton zones was slightly higher than with Models 4.5, 4.6, or 4.7. This model explained 95, 82, 73, 92, 87, and 61 percent of the variation in cotton acreage for East Buganda, Busoga, Teso, Lango, West Nile, and Bunyoro respectively. There was not evidence of autocorrelation in the Estimating Equation 4.8.

Results of Acreage Model: Double-Logarithmic Formulation of Models 4.5, 4.6, and 4.7

Since it is possible that a multiplicative relationship applies between the dependent variable of acreage and the postulated determinant variables, Estimating Equations 4.5, 4.6, and 4.7 were also tested on annual data from 1950 to 1974 in double-logarithmic formulation. The linear formulation of Estimating Equations 4.5 and 4.8 included a zero-one dummy variable. This variable was introduced to test whether or not the intercepts $\gamma\pi_{io}$ shifted as a result of the double production policy. However, it is not possible to apply multiplicative estimation procedures to zero factors. The dummy variable was, therefore, excluded from the Models 4.5 and 4.8.[1] The results of this section of the analysis are

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[1]The exclusion of the dummy variable from Models 4.5 and 4.8 reduces these to Models 4.5 (without the dummy variable) and 4.7 respectively.

presented in Tables 5.5, 5.6, and 5.7.

Generally, the double-logarithmic form of Model 4.5 did not improve the results obtained from the linear form of this particular model. The general relationship, however, was significant at the 0.05 level and there was no autocorrelation as indicated by the Durbin Watson statistic. The estimated coefficients retained their signs as reported in Tables 5.1 to 5.4 inclusive. In some few instances the level of significance of the estimated coefficients varied from those previously reported. These differences, as with those from the other model formulations tested, are more explicitly compared in later sections of this chapter.

The estimated coefficients of the "price index for cotton" in the acreage response functions for East Buganda, Lango, West Nile, and Bunyoro, were all significantly different from zero at the 0.05 level of significance. The estimated coefficients of the variables "price of staple food crops" in the acreage response function for Teso and West Nile were significant at the 0.05 and 0.10 levels respectively. In all other Zones, the estimated coefficients of this variable were not significantly different from zero.

Table 5.6 presents the results of the acreage response functions when the variable of "land under cultivation" is included--Estimating Equation 4.6. As in the results shown in Tables 5.2, 5.3, and 5.4, the variable "land under cultivation" was negatively related to the dependent variable of "cotton acreage" in the case of the East Buganda, Busoga, Lango, West Nile, and Bunyoro cotton zones. The relationship remained

Table 5.5

ESTIMATED COTTON ACREAGE RESPONSE FUNCTIONS (DOUBLE-LOG) BY ZONE

MODEL 4.5: $\log A_t = \log \gamma\pi_0 + \gamma\pi_1 \log P_{t-1} + (1-\gamma)\log A_{t-1} + \gamma\pi_5 \log PF_{t-1} + \gamma\pi_6 \log PZ_{t-1} + \nu'_t$

Cotton Zone	Estimated Regression Coefficients[a]					R^2	DW[b]
	Intercept	$\log P_{t-1}$	$\log A_{t-1}$	$\log PF_{t-1}$	$\log PZ_{t-1}$		
East Buganda	-2.15727	0.9719*** (0.3570)	0.6617** (0.2647)	0.1410 (0.2158)	-0.1273 (0.2658)	0.9424	2.320†
Busoga	0.78881	0.0205 (0.2761)	0.5795*** (0.1970)	-0.1452 (0.1253)	0.0902 (0.1074)	0.7313	2.208†
Teso	2.64801	0.2253 (0.3617)	0.3755* (0.2635)	-0.2584** (0.1255)	-0.1846 (0.1850)	0.7005	2.169†
Lango	0.44539	0.3918*** (0.1457)	0.3537** (0.1524)	0.0469 (0.0594)	-0.0272 (0.0461)	0.8964	1.642†
West Nile	0.68438	0.3770*** (0.1423)	0.0633 (0.1760)	0.1151* (0.0740)	-0.0689 (0.0688)	0.7767	1.469†
Bunyoro	-0.44863	0.8922** (0.3839)	0.0091 (0.2394)	0.0279 (0.1587)	-0.1840 (0.1801)	0.5159	1.600†

[a]Standard errors are in parentheses.
[b]Durbin Watson statistic.
***Coefficients are significant at the 0.01 level.
**Coefficients are significant at the 0.05 level.
*Coefficients are significant at the 0.10 level.
†The hypothesis of no serial correlation is acceptable.

Table 5.6

ESTIMATED COTTON ACREAGE RESPONSE FUNCTIONS (DOUBLE-LOG) BY ZONE

MODEL 4.6 $\log A_t = \log\gamma\pi_0 + \gamma\pi_1 \log P_{t-1} + (1-\gamma)\log A_{t-1} + \gamma\pi_4 \log M_t + \gamma\pi_5 \log PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \nu_t'$

Cotton Zone	Estimated Coefficients[a]						R^2	DW[b]
	Intercept	$\log P_{t-1}$	$\log A_{t-1}$	$\log M_t$	$\log PF_{t-1}$	$\log PZ_{t-1}$		
East Buganda	1.76689	0.8554** (0.3644)	0.6556*** (0.2447)	-1.6097 (1.2984)	0.1560 (0.2131)	-0.1566 (0.2632)	0.9469	2.056†
Busoga	2.51069	0.0415 (0.2797)	0.5246*** (0.2096)	-0.8170 (0.9947)	-0.0563 (0.1664)	0.1236 (0.1157)	0.7410	2.071†
Teso	-3.41937	0.0913 (0.4217)	0.4291* (0.2682)	2.2530 (2.1904)	-0.2160* (0.1320)	-0.3008* (0.2165)	0.7172	2.267†
Lango	3.04122	0.3654*** (0.1367)	0.2185* (0.1582)	-0.9943** (0.5091)	0.0043 (0.0460)	-0.1032* (0.0625)	0.9145	1.666†
West Nile	3.07004	0.2433* (0.1468)	0.1393 (0.1903)	-0.8056** (0.3920)	0.1231** (0.0685)	-0.0800 (0.0638)	0.8191	1.367††
Bunyoro	2.76808	0.8133** (0.3877)	0.0325 (0.2407)	-1.5012 (1.3404)	0.0997 (0.1701)	-0.2883* 0.2017	0.5475	1.673†

[a]Standard errors are in parentheses.
[b]Durbin Watson statistic.
***Coefficients are significant at the 0.01 level.
**Coefficients are significant at the 0.05 level.
*Coefficients are significant at the 0.10 level.
†The hypothesis of no serial correlation is accepted.
††Tests for serial correlation are inconclusive.

Table 5.7

ESTIMATED COTTON ACREAGE RESPONSE FUNCTIONS (DOUBLE-LOG) BY ZONE, MODEL 4.7:

$$\log A_t = \log\gamma\pi_0 + \gamma\pi_1 \log P_{t-1} + \gamma\pi_2 \log W_{t-1} + (1-\gamma)\log A_{t-1} + \gamma\pi_4 \log M_t + \gamma\pi_5 \log PF_{t-1} + \gamma\pi_6 \log PZ_{t-1} + v_t'$$

Cotton Zone	Estimated Regression Coefficients[a]							R^2	DW[b]
	Intercept	$\log P_{t-1}$	$\log W_{t-1}$	$\log A_{t-1}$	$\log M_t$	$\log PF_{t-1}$	$\log PZ_{t-1}$		
East Buganda	1.95463	0.8498** (0.3722)	0.1124 (0.2140)	0.6727*** (0.2323)	-1.8379 (1.3948)	0.1734 (0.2201)	-0.1815 (0.2728)	0.9477	2.139††
Busoga	2.6698	0.0490 (0.2909)	0.0464 (0.2709)	0.5340*** (0.2225)	-0.8760 (1.0788)	-0.0526 (0.1724)	-0.1375 (0.1439)	0.7414	2.090†
Teso	-3.27956	0.0415 (0.4435)	0.0997 (0.2982)	0.4332* (0.2754)	2.2190 (2.2488)	-0.1783 (0.1763)	-0.3063* (0.2227)	0.7190	2.239††
Lango	3.56144	0.3442*** (0.1357)	0.1261 (0.1013)	0.1284 (0.1718)	-1.2010*** (0.5282)	0.1204** (0.0631)	-0.0322 (0.0539)	0.9216	1.551††
West Nile	3.64150	0.2616** (0.1427)	0.1187* (0.084)	0.1359 (0.1844)	-1.0036*** (0.4027)	0.1582*** (0.0540)	-0.0848* (0.0619)	0.8397	1.534††
Bunyoro	2.98276	0.8357** (0.3919)	0.2350 (0.282)	0.1080 (0.2483)	-1.4942 (1.3520)	0.1812 (0.1975)	-0.2569 (0.2069)	0.5652	1.783††

[a] Standard errors are in parentheses.
[b] Durbin Watson statistic
***Coefficients are significant at the 0.01 level.
**Coefficients are significant at the 0.05 level.
*Coefficients are significant at the 0.10 level.
†The hypothesis of no serial correlation is acceptable.
††Tests for serial correlation are inconclusive.

positive and not sifnificantly different from zero in the case of the Teso zone. The estimated coefficients of this variable for Lango and West Nile were significantly different from zero at the 0.05 level. There was no evidence of autocorrelation from this estimating equation.

The results of Estimating Equation 4.7, tested in double-logarithmic form are presented in Table 5.7. In all cases, the estimated coefficients of the variable of "world cotton price index" were not significantly different from zero at acceptable levels of significance. However, tests for autocorrelation were inconclusive.

In general, as with the linear formulation, the testing of the double-logarithmic formulation suggested a fairly plausible fit to the data and there are few major differences between the two model forms. The regressors in all cases accounted for over 50 percent of the variability in the regressands, and the models were significant as measured by the F-test at the 0.05 level of significance.

Results of Acreage Response Model: Semi-Logarithmic Formulation of Models 4.5, 4.6, 4.7, and 4.8

In the formulation of the linear estimating equations, it was implicitly assumed that the rate of change of acreage (A_t) with respect to any independent variable is constant. In contrast, the double-logarithmic equation formulation implicitly assumed that the elasticities of the dependent variable "cotton acreage," with respect to any

independent variables, are constant. Since these implicit constraints may not be applicable, the models were also tested in a semi-logarithmic formulation. The results generated from the application of the semi-logarithmic models to annual data from 1950 to 1974 are presented in Tables 5.8, 5.9, 5.10, and 5.11.

The results from this model formulation did not deviate greatly from those obtained from the application of the double-logarithmic formulation. The signs on the estimated coefficients were consistent with those obtained from the linear and double-logarithmic formulations. The extent of variation explained by the independent variables varied between 52 and 94 percent (see Tables 5.8 to 5.11 inclusive).

As with the previously outlined model forms, when the variable "land under cultivation" was included in Estimating Equation 4.5 to form Estimating Equation 4.6, the results indicated a decline of about 0.5 to 2 percent in the magnitude of the coefficients of determination; however, the overall relationship remained significant at the 0.05 level. The Durbin Watson statistic indicated no evidence of autocorrelation.

The results of Model 4.7 are presented in Table 5.10. This model includes "world cotton price" as one explanatory variable. The estimated coefficients of this variable were not significantly different from zero. However, the signs on the estimated coefficients were positive, as was the case in the linear and double-logarithmic formulations. Except in the case of East Buganda, the test for serial correlation gave no conclusive results.

Table 5.8

ESTIMATED COTTON ACREAGE RESPONSE FUNCTIONS BY ZONE

MODEL 4.5 $\log A_t = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \gamma\pi_7 DC_t + \nu_t'$

Cotton Zone	Estimated Regression Coefficients[a]						R^2	DW[b]
	Intercept	P_{t-1}	A_{t-1}	PF_{t-1}	PZ_{t-1}	DC_t		
East Buganda	1.14924	0.0031*** (0.0012)	0.0030** (0.0012)	0.0001 (0.0010)	-0.0005 (0.0006)	-0.1278** (0.0661)	0.9431	1.846†
Busoga	1.40249	0.0010 (0.0010)	0.0041*** (0.0011)	-0.0002 (0.0004)	0.0010 (0.0009)	-0.0765 (0.0732)	0.7704	2.503††
Teso	2.11280	0.0001 (0.0010)	0.0007 (0.0010)	-0.0004 (0.0005)	-0.0005 (0.0008)	-0.1051 (0.0754)	0.7739	2.032†
Lango	1.66940	0.0018*** (0.0004)	0.0010** (0.0005)	0.0005** (0.0002)	-0.0004*** (0.0002)	-0.0306* (0.0214)	0.9308	1.804†
West Nile	1.43998	0.0018*** (0.0004)	0.0009 (0.0014)	0.0005** (0.0002)	-0.0001 (0.0003)	-0.0777 (0.0233)	0.8693	1.589††
Bunyoro	1.42926	0.0030*** (0.0010)	0.0001 (0.0024)	0.0012 (0.0010)	-0.0008 (0.0009)	-0.0312 (0.1323)	0.5166	1.738†

[a]Standard errors are in parentheses.
[b]Durbin Watson statistic.
***Coefficients are significant at the 0.01 level.
**Coefficients are significant at the 0.05 level.
*Coefficients are significant at the 0.10 level.
††Tests for serial correlations are inconclusive
†The hypothesis of no serial correlation is acceptable.

Table 5.9

ESTIMATED COTTON ACREAGE RESPONSE FUNCTIONS (SEMI-LOG) BY ZONE

MODEL 4.6 $\log A_t = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_4 M_t + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \nu_t'$

Cotton Zone	Estimated Regression Coefficients[a]						R^2	DW[b]
	Intercept	P_{t-1}	A_{t-1}	M_t	PF_{t-1}	PZ_{t-1}		
East Buganda	2.63714	9.0024** (0.0012)	0.0026** (0.0012)	-0.0088* (0.0045)	0.0015 (0.0012)	-0.0006 (0.0006)	0.9432	1.946†
Busoga	1.70205	0.0006 (0.0010)	0.0038*** (0.0012)	-0.0011 (0.0019)	-0.0003 (0.0004)	0.0010 (0.0010)	0.7606	2.177†
Teso	1.39783	0.0002 (0.0013)	0.0009 (0.0010)	0.0023 (0.0031)	-0.0006 (0.0005)	-0.0010 (0.0011)	0.7569	2.260†
Lango	2.17977	0.0015*** (0.0004)	0.0005 (0.0005)	-0.0016** (0.0007)	0.0006*** (0.0003)	-0.0003* (0.0002)	0.9388	1.633†
West Nile	2.08164	0.0006 (0.0005)	0.0023 (0.0018)	-0.0024** (0.0012)	0.0006** (0.0003)	-0.0006** (0.0003)	0.8269	1.772†
Bunyoro	1.73016	0.0026 (0.0016)	0.0004 (0.0018)	-0.0013 (0.0037)	0.0011 (0.0009)	-0.0008 (0.0008)	0.5183	1.697†

[a] Standard errors are in parentheses.
[b] Durbin Watson statistic.
***Coefficients are significant at the 0.01 level.
**Coefficients are significant at the 0.05 level.
*Coefficients are significant at the 0.10 level.
†The hypothesis of no serial correlation is acceptable.

Table 5.10

ESTIMATED COTTON ACREAGE RESPONSE FUNCTIONS (SEMI-LOG) BY ZONE

MODEL 4.7: $\log A_t = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + \gamma\pi_2 W_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_4 M_t + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \nu'_t$

Cotton Zone	Estimated Regression Coefficients[a]							R^2	DW[b]
	Intercept	P_{t-1}	W_{t-1}	A_{t-1}	M_t	PF_{t-1}	PZ_{t-1}		
East Buganda	2.64338	0.0026** (0.0013)	0.0004 (0.0010)	0.0027** (0.0013)	-0.0089** (0.0046)	0.0016 (0.0013)	-0.0006 (0.0006)	0.9437	1.914†
Busoga	1.64107	0.0006 (0.0010)	0.0003 (0.0010)	0.0037*** (0.0013)	-0.0008 (0.0021)	-0.0004 (0.0004)	0.0010 (0.0010)	0.7623	2.188††
Teso	1.43901	0.0002 (0.0014)	0.0007 (0.0011)	0.0007 (0.0011)	0.0022 (0.0031)	-0.0008* (0.0006)	-0.0010 (0.0010)	0.7636	2.296††
Lango	2.18082	0.0015*** (0.0004)	0.0001 (0.0003)	0.0005 (0.0006)	-0.0016** (0.0008)	0.0006* (0.0003)	-0.0008*** (0.0002)	0.9388	1.628††
West Nile	2.09531	0.0007* (0.0005)	0.0003 (0.0003)	0.0021 (0.0018)	-0.0026** (0.0012)	0.0007** (0.0003)	-0.0006* (0.0003)	0.8366	1.820††
Bunyoro	1.67646	0.0031* (0.0017)	0.0011 (0.0011)	0.0001 (0.0018)	-0.0010 (0.0037)	0.0011 (0.0009)	-0.0005 (0.0008)	0.5438	1.774††

[a] Standard errors are in parentheses.
[b] Durbin Watson statistic
***Coefficients are significant at the 0.01 level.
**Coefficients are significant at the 0.05 level.
*Coefficients are significant at the 0.10 level.
†The hypothesis of no serial correlation is accepted.
††Tests for serial correlation are inconclusive.

Table 5.11

ESTIMATED COTTON ACREAGE RESPONSE FUNCTIONS (SEMI-LOG) BY ZONE

MODEL 4.8: $\log A = \gamma\pi_0 + \gamma\pi_1 P_{t-1} + \gamma\pi_2 W_{t-1} + (1-\gamma)A_{t-1} + \gamma\pi_4 M_t + \gamma\pi_5 PF_{t-1} + \gamma\pi_6 PZ_{t-1} + \gamma\pi_7 DC_t + v_t^*$

Cotton Zone	Estimated Regression Coefficients[a]								R^2	DW[b]
	Intercept	P_{t-1}	W_{t-1}	A_{t-1}	M_t	PF_{t-1}	PZ_{t-1}	DC_t		
East Buganda	2.05499	0.0029**	0.0001	0.0029**	-0.0056	0.0011	-0.0005	-0.0757	0.9460	1.836††
		(0.0014)	(0.0010)	(0.0013)	(0.0061)	(0.0014)	(0.0007)	(0.0903)		
Busoga	1.71330	0.0009	0.0002	0.0036***	-0.0015	-0.0002	0.0014	-0.0912	0.7806	2.379††
		(0.0011)	(0.0010)	(0.0013)	(0.0021)	(0.0005)	(0.0011)	(0.0791)		
Teso	1.49579	0.0001	0.0007	0.0005	0.0019	-0.0004	-0.0010	-0.0986	0.7849	2.102††
		(0.0014)	(0.0010)	(0.0011)	(0.0031)	(0.0007)	(0.0011)	(0.0784)		
Lango	2.11383	0.0016***	0.0001	0.0006	-0.0014*	0.0006**	-0.0003*	-0.0094	0.9392	1.689††
		(0.0005)	(0.0004)	(0.0006)	(0.0010)	(0.0003)	(0.0002)	(0.0286)		
West Nile	1.75067	0.0014***	0.0002	0.0017	-0.0014	0.0006**	-0.0002	-0.0637	0.8799	1.661††
		(0.0005)	(0.0003)	(0.0016)	(0.0012)	(0.0003)	(0.0003)	(0.0265)		
Bunyoro	1.51418	0.0032**	0.0011	0.0002	-0.0009	0.0012	-0.0004	-0.0270	0.5449	1.821††
		(0.0018)	(0.0012)	(0.0026)	(0.0038)	(0.0010)	(0.0010)	(0.1370)		

[a]Standard errors are in parentheses.

[b]Durbin Watson Statistic.

***Coefficients are significant at the 0.01 level.

**Coefficients are significant at the 0.05 level.

*Coefficients are significant at the 0.10 level.

††Tests for serial correlation are inconclusive.

Estimating Equation 4.8 provided a reasonable fit to the data. The coefficients of determination were approximately 95, 78, 79, 94, 88, and 54 percent for East Buganda, Busoga, Teso, Lango, West Nile, and Bunyoro respectively. The postulated relationship was significant at the 0.05 level in each case; however, the Durbin Watson test indicated inconclusive evidence regarding autocorrelation. The results of this analysis are presented in Table 5.11.

In conclusion, the linear, double-logarithmic, and semi-logarithmic formulations of the models all provide a fairly good fit to the data, although several of the estimated coefficients, particularly those for the variable of "price of staple and other food crops" are not significant. In most cases, the estimated coefficients had signs consistent with economic theory. In most instances, the null hypothesis for serial correlation was accepted. Some confidence can therefore be placed on Models 4.5 to 4.8 inclusive for prescriptive and, to a limited extent, predictive purposes.

Estimated Coefficients of Adjustment

Estimating Equations 4.5 to 4.8 inclusive give an indication of the effects of the technological and institutional limitations involved in adjusting cotton acreages toward the desired level in response to changing economic conditions. The rate at which adjustment takes place over the period of analysis is measured by the value of the coefficient of adjustment, γ. As indicated in Chapter III, the coefficient of

adjustment is obtained by subtracting the statistically-determined regression coefficient of the lagged dependent variable from one. The closer the value of γ is to unity, the more complete is the adjustment within the given time period. The closer the value of γ is to zero, the slower is the rate of adjustment.[1] The magnitude of the coefficient of adjustment is a significant factor in calculating the short- and long-run elasticities of supply. The mathematical formulae are outlined in the preceding chapter (see Equations 4.12 and 4.13).

Table 5.12 presents the estimates of the coefficients of adjustment, γ. These estimates were calculated from the results of the linear and double-logarithmic forms of the acreage response functions. Estimates for East Buganda and Busoga are statistically significant at the 0.01 level and over. In the case of these two zones, the magnitude and significance of the estimated adjustment coefficients suggest that producers are fairly responsive to changes in economic conditions, whether they be for technological or institutional reasons. Estimates for Lango and Teso, though relatively larger than those for East Buganda and Busoga, were significantly different from zero at relatively lower levels. The largest estimates of adjustment coefficients were for West Nile and Bunyoro and these were not significantly different from zero. This feature appears to suggest that the partial

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[1]M. E. Dalton, and L. F. Lee, "Projecting Sheep Numbers Shorn--an Economic Model," *Quarterly Review of Agricultural Economics*, Vol. xxviii, No. 4 (Australia: October, 1975), pp. 225-239.

Table 5.12

COEFFICIENTS OF ADJUSTMENT BY ZONE (FROM LINEAR AND DOUBLE-LOGARITHMIC MODEL FORMULATIONS

Model Form/ Equation	Coefficients of Adjustment					
	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro
Linear						
4.5	0.4097***	0.3650***	0.7982	0.6790***	0.9404	0.8932
4.6	0.4315***	0.4302***	0.7660	0.7680*	0.8062*	0.9462
4.7	0.4449***	0.4544***	0.7759	0.7564*	0.8288	0.9883
4.8	0.4476***	0.4117***	0.8096	0.7520**	0.8687	0.8840
Double-Logarithmic						
4.5	0.3383**	0.4205***	0.6245*	0.6463**	0.9367	0.9919
4.6	0.3444***	0.4754***	0.5709*	0.7815*	0.8607	0.9675
4.7	0.3273***	0.4660***	0.5668*	0.8716	0.8641	0.8920

***Coefficients of adjustment based on regression coefficients significant at 0.01 level.

**Coefficients of adjustment based on regression coefficients significant at 0.05 level.

*Coefficients of adjustment based on regression coefficients significant at 0.10 level.

adjustment hypothesis may not be applicable to data from the West Nile and Bunyoro cotton zones. The recommended cotton planting dates for these zones lie between April and the second week of the month of May each year. These dates are sufficiently early so that by the time the new cotton price is announced, sometime in July, it may not be possible for the producers to adjust their production plans--cotton is already in the growing stages. The estimates of γ, though non-significant, tend to be closer to unity for these two zones, suggesting that adjustment is completed within one year. Generally, those coefficients of adjustment which are based on highly significant estimated regression coefficients (those for East Buganda and Busoga) are comparable to similar estimates of the coefficients of adjustment obtained for cotton and other cash crops in tropical Africa, Asia, and the United States.[1]

Estimated Short- and Long-Run Own-Price Elasticities of Acreage for Cotton

An advantage of the partial adjustment model which was used in this analysis of acreage response is that in estimating supply responses it allows both short- and long-run reactions to be explored. Thus, the short-run and long-run acreage elasticities were computed from the

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[1]For a comparison of the magnitude of the coefficients of adjustment derived from a number of studies of supply respcse, see:

Raj Krishna, "Farm Supply Response in India-Pakistan: A Case Study of the Punjab Region," *Readings in Economics of Agriculture*, pp. 84-85.

Marc Nerlove, "Estimated Elasticities of Supply of Selected Agricultural Commodities," *Readings in Economics of Agriculture*, pp. 72-73.

analysis presented in the previous sections of this chapter. These parameters were based on the estimated coefficients of the cotton price variable from the linear and double-logarithmic forms of the acreage response functions. The results are presented in Tables 5.13 and 5.14.

As expected, the computed long-run elasticities are larger than the short-run elasticities. The short-run elasticities for the East Buganda and Bunyoro cotton zones ranged between 0.5879 and 0.9719, while those for the long-run varied between 0.7302 and 2.8729 respectively. The feature that the estimates of own-price elasticities are substantially larger for these two zones than for other zones might be explained by the following factor: farmers in the East Buganda and Bunyoro zones have a wide range of alternative crops, such as maize, beans, sweet potatoes, and groundnuts, which may be readily substitutable in production. Some of these crops--maize and beans--are relatively less labour intensive[1] and have shorter production periods than does cotton. The apparent fairly-elastic long-run supply responses for cotton in these zones, and particularly for East Buganda, are consistent with the feature that over time, cotton has tended to decline in importance and thus comprises a smaller proportion of farm production in those zones. This feature is observed in the declining trends of cotton acreages in East Buganda and Bunyoro. The area under cotton in East Buganda, for example, dropped from an average of 0.93 Ha per agricultural holding in 1950 to 0.16 Ha per agricultural holding in 1974. The double-logarithmic form

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[1]Planning Unit, Ministry of Agriculture and Forestry, *Crop Production Costs and Returns Analysis* (Entebbe: Research Section, 1975), pp. 23-25.

Table 5.13

SHORT-RUN OWN-PRICE ELASTICITIES FOR COTTON BY ZONE

Model Form/ Equation	Short-Run Own-Price Elasticities					
	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro
Linear						
4.5	0.6986**	0.2476	0.0257	0.4957***	0.4821***	0.8216***
4.6	0.6948***	0.1603**	0.1015	0.4350***	0.1761	0.6909**
4.7	0.5879***	0.1573**	0.1365	0.4372***	0.2198	0.8172**
4.8	0.5266	0.1846	0.1323	0.4498***	0.3888***	0.8616**
Double-Logarithmic						
4.5	0.9719***	0.0205	0.2253	0.3918***	0.3770***	0.8922***
4.6	0.8554***	0.0415	0.0913	0.3654***	0.2433	0.8133*
4.7	0.8498***	0.0490	0.0415	0.3442***	0.2616**	0.8357***

***Elasticity based on regression coefficients significant at 0.010 level.

**Elasticity based on regression coefficients significant at 0.050 level.

*Elasticity based on regression coefficients significant at 0.100 level.

Table 5.14

LONG-RUN OWN-PRICE ELASTICITIES FOR COTTON BY ZONE

Model Form/ Equation	Long-Run Own-Price Elasticities					
	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro
Linear						
4.5	1.7052**	0.6783	0.0322	0.7300***	0.5126***	0.9198***
4.6	1.6102***	0.3726**	0.1325	0.5605***	0.2184	0.7302**
4.7	1.3214***	0.3462**	0.1759	0.5780***	0.2652	0.8269**
4.8	1.1765	0.4484	0.1634	0.5981***	0.4476***	0.9747**
Double-Logarithmic						
4.5	2.8729***	0.0487	0.3607	0.6160***	0.4025***	0.8995***
4.6	2.4841***	0.0873	0.1599	0.4676***	0.2827	0.8406*
4.7	2.5963***	0.1051	0.7320	0.3949***	0.3027**	0.9369***

***Elasticity based on regression coefficients significant at 0.01 level.

**Elasticity based on regression coefficients significant at 0.05 level.

*Elasticity based on regression coefficients significant at 0.10 level.

of the estimating models applied to East Buganda data provided more elastic supply response estimates than did the linear model. In the case of Bunyoro, the responses calculated from these two model forms were almost equal in magnitude.

The estimates of short-run and long-run own-price elasticities of acreage for Lango and West Nile which were generated by the linear model were slightly larger than those generated by the double-logarithmic formulation. The short-run estimates for Lango and West Nile ranged between 0.3442 and 0.4957, and 0.2616 and 0.4821 respectively. The long-run estimates for the two zones ranged from 0.3949 to 0.7300 for Lango, and from 0.3027 to 0.5126 for West Nile. The magnitude of these estimated acreage response elasticities with respect to price suggests that cotton acreage is fairly sensitive to price changes.

Estimated supply elasticities for Teso were relatively low and were based on coefficients which were not significantly different from zero. For Busoga, Estimating Equations 4.6 and 4.7 in their linear formulation generated coefficients which were significant at the 0.05 level; on the basis of these coefficients, the relatively low elasticities of 0.1603 and 0.1573 for Busoga were computed. Compared to the other zones, the estimated elasticities of supply for Busoga and Teso are relatively low in magnitude. The implication of this feature is that change in price paid to growers for their cotton is likely to be accompanied by very small changes in the acreage committed to cotton. Cotton in these two zones appears to have a relatively more stable production pattern over time and to comprise a larger proportion of farm production than in other cotton zones. These zones, particularly Teso,

have relatively fewer production alternatives to cotton than do the other zones.

The overall implication of this section of analysis is that in those cotton areas where there is evidence of relatively more responsive acreage functions for cotton, and where cotton tends to have production alternatives, cotton has, by and large, tended to lose its relative position on the farmers' agricultural holdings and the area under cultivation to cotton has been gradually declining. The major cause of this decline appears to be due to the competition which cotton faces from other crops. The following section of this chapter presents the results of the tests of the relationships which apply between the acreage of cotton and the prices of staple and other selected food crops.

Estimated Short- and Long-run Cross Elasticities of Cotton Acreage With Respect to Prices of Staple and Other Food Crops

Estimates of short- and long-run cross price elasticities were calculated to test the relationships between changes in prices of staple and other food crops and cotton acreage. The results are presented in Tables 5.15 through 5.18 inclusive.

The staple food crops included in this analysis (see Appendix VI) are bananas for East Buganda and Busoga, finger millet for Teso, Lango, and Bunyoro, and cassava for the West Nile zone. Many of the computed cross price elasticities are based on coefficients which were not significantly different from zero. Thus, conclusions based on these elasticities must be cautious. However, in a few cases, specifically with coefficients of the prices of bananas in East Buganda and with finger

Table 5.15

SHORT-RUN CROSS ELASTICITY ESTIMATES FOR COTTON WITH RESPECT TO STAPLE FOOD CROPS

Model Form/ Equation	Short-Run Cross Price Elasticity					
	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro
	Bananas	Bananas	Finger Millet	Finger Millet	Cassava	Finger Millet
Linear						
4.5	0.2413	-0.3114	-0.1341	0.1274	0.1137**	0.3175
4.6	0.4545**	-0.2800	-0.2420	0.1449	0.1218**	0.2679
4.7	0.4275	-0.3206	-0.4480	0.1451	0.1387**	0.2648
4.8	0.5964**	-0.3392	-0.2758	0.1495	0.1328***	0.3080
Double-Logarithmic						
4.5	0.1410	-0.1452	-0.2584**	0.0469	0.1151*	0.0279
4.6	0.1560	-0.0563	-0.2160*	0.0043	0.1321**	0.0997
4.7	0.1734	-0.0526	-0.1783	0.1204*	0.1582***	0.1812

***Elasticities based on coefficients significant at 0.010 level.

**Elasticities based on coefficients significant at 0.050 level.

*Elasticities based on coefficients significant at 0.100 level.

Table 5.16

LONG-RUN CROSS ELASTICITY ESTIMATES FOR COTTON
WITH RESPECT TO STAPLE FOOD CROPS

Model Form/ Equation	Long-Run Cross Price Elasticity					
	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro
	Bananas	Bananas	Finger Millet	Finger Millet	Cassava	Finger Millet
Linear						
4.5	0.5890	-0.8532	-0.1680	0.1876	0.1209**	0.3555
4.6	1.0533**	-0.6509	-0.3159	0.1887	0.1511**	0.2831
4.7	0.9609	-0.7055	-0.5774	0.1918	0.1673**	0.2679
4.8	1.3324**	-0.8239	-0.3407	0.1988	0.1529***	0.3484
Double-Logarithmic						
4.5	0.4168	-0.3453	-0.4138**	0.0727	0.1229*	0.0281
4.6	0.4529	-0.1184	-0.3873*	0.0055	0.1430**	0.1030
4.7	0.5298	-0.1129	-0.3146	0.1381*	0.1831***	0.2031

***Elasticity based on regression coefficients significant at 0.010 level.

**Elasticity based on regression coefficients significant at 0.050 level.

*Elasticity based on regression coefficients significant at 0.100 level.

Table 5.17

SHORT-RUN CROSS ELASTICITY ESTIMATES FOR COTTON
WITH RESPECT TO OTHER SELECTED FOOD CROPS

Model Form/ Equation	Short-Run Cross Elasticity					
	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro
	Sweet Potatoes	Groundnuts	Groundnuts	Groundnuts	Finger Millet	Groundnuts
Linear						
4.5	-0.1349	0.4518*	-0.0733	-0.0672	-0.0050	-0.1288
4.6	-0.0779	0.3480*	-0.1212	-0.0430	-0.1293**	-0.1683
4.7	-0.0971	0.3798*	-0.1213	-0.0395	-0.1202	-0.0837
4.8	-0.1593	0.4816*	-0.1143	-0.0438	-0.0338	-0.0154
Double-Logarithmic						
4.5	-0.1273	0.0902	-0.1846*	-0.0272*	-0.0689	-0.1840
4.6	-0.1566	0.1236	-0.3008*	-0.1032	-0.0800	-0.2883*
4.7	-0.1815	0.1375	-0.3063*	-0.0322	-0.0848*	-0.2569

**Elasticity based on coefficients significant at 0.050 level.

*Elasticity based on coefficients significant at 0.100 level.

Table 5.18

LONG-RUN CROSS ELASTICITY ESTIMATES FOR COTTON
WITH RESPECT TO OTHER SELECTED FOOD CROPS

Model Form/ Equation	Long-Run Cross Elasticity					
	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro
	Sweet Potatoes	Groundnuts	Groundnuts	Groundnuts	Finger Millet	Groundnuts
Linear						
4.5	-0.3293	1.2378*	-0.0918	-0.1000	-0.0053	-0.1442
4.6	-0.1805	0.8089*	-0.1582	-0.0550	-0.1604**	-0.1779
4.7	-0.2182	0.8358*	-0.1563	-0.0522	-0.1450	-0.0847
4.8	-0.3559	1.1698*	-0.1418	-0.0582	-0.0387	-0.0174
Double-Logarithmic						
4.5	-0.3763	0.2145	-0.2956*	-0.0421	-0.0736	-0.1855
4.6	-0.4547	0.2560	-0.5269*	-0.1321	-0.0929	-0.2979
4.7	-0.5545	0.2950	-0.5404*	-0.0369	-0.0981*	-0.2880

**Elasticity based on coefficients significant at 0.050 level.

*Elasticity based on coefficients significant at 0.100 level.

millet in Teso and Lango, the estimates were significant at the 0.10 level. The coefficients of the prices of cassava in West Nile were statistically significant at relatively acceptable levels. Except in the cases of the prices of bananas in Busoga and of finger millet in Teso, cotton acreage responded positively to price changes of these other staple food crops. These relationships were consistent over both the linear and double-logarithmic forms of the models. From observation in Uganda, producers of bananas in Busoga and of finger millet in Teso appear to derive a substantial amount of income from these two crops and hence a negative relationship obtained between cotton and these two crops.

Generally, however, a qualified conclusion about the degree of competition between cotton and production of bananas in Busoga and finger millet in Teso may not be possible from the available empirical results. Most of the estimated cross price elasticities, though having negative signs, were not derived from price coefficients which were significantly different from zero at acceptable levels of significance.

The elasticities of cotton acreage with respect to the prices of those other major food crops which also provide substantial income to the growers are presented in Tables 5.17 and 5.18. The results from the linear and double-logarithmic forms of Estimating Equations 4.5 to 4.8 generated estimates of cross price elasticities of cotton acreage with respect to the prices of groundnuts in Busoga which were positive. Groundnuts in this zone are a stable and important food crop. In fact, this zone alone produces 25 to 35 percent of the country's total groundnut production. It is likely that, because of its stability on the farmers' holdings, the crop may not compete with cotton at the farm level.

However, the long-run cross acreage elasticities with respect to prices of groundnuts were relatively elastic varying between 0.8089 and 1.2378 for the linear form of the models. This suggests that the crop may be sensitive to other economic incentives including cotton.

The cross elasticities of acreage with respect to the prices of other selected food crops in Teso, Lango, East Buganda, West Nile, and Bunyoro, were not based on significant price coefficients. Although the signs were consistently negative, any conclusion about the degree of possible competition between cotton acreage and these selected food crops must be treated with caution. The results of this section of analysis are presented in Tables 5.17 and 5.18.

Estimated Yield Functions and Empirical Results of Yield Tests

With the apparent long-run decline of cotton production in Uganda, year-to-year fluctuations in cotton yields must be given special consideration. Although it is generally believed that weather factors have been the major causes of severe and sometimes sudden fluctuations in crop production, it is not known whether or not annual variations in weather itself have had random effects on cotton yields. An analysis of average yields in the major cotton growing areas of Uganda would provide some information about the supply of cotton in the country. Secondly, a knowledge of the apparent form of the yield function for cotton could provide some basis for analysing supply responses. For example, Trescott[1]

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[1]Paul B. Trescott, "Rice Yield and Productivity: Evidence and Analysis," *Economic Journal*, Vol. 3, No. 1 (Economic Association of Thailand, 1967), pp. 37-43.

points out that a significantly positive relationship between yield per unit of area and time may reflect the contributions of technological improvement. This section of the study presents the results of some empirical tests on cotton yields.

The Results of Yield Tests

In specifying the general yield function (4.10):

$YE_t = \beta_0 + \beta_1\overline{YE}_t + \beta_2 WE_t + \beta_3 t + \mu_t$, it was assumed that there are two basic groups of factors which influence the dependent variable "yield." These are the group of systematic factors which are included in the independent variables and the group of unsystematic (or random) factors which are usually represented in the random disturbances, μ_t.

The presence of serial correlation in the error terms indicates that there is some systematic (non-random) influence represented in these terms.[1] As a result, the model may be misspecified or the data may possess some important information on the behaviour of random disturbances.[2]

In this analysis, the presence of serial correlation in Estimating Equation 4.9, together with evidence of skewness in the yield data, is treated as an indicator of bunchiness in the data. These two tests suggest that, at least, the question of whether or not changes in rainfall

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[1]Considering the yield function 4.10, if serial correlation applies, the disturbance terms μ_{it} no longer fulfill the assumption of mutual independence. These would then be linearly dependent in the form of: $\mu_t = \hat{\rho}\mu_{t-1} + \nu_t$ where $|\hat{\rho}| < 1$; and $E(\nu_t) = 0$; $E(\nu_t \nu_{t+Q}) = 0$ for all t when $Q \neq 0$. This implies that μ_t is systematically dependent on μ_{t-1} and is explained by the coefficient, $\hat{\rho}$.

[2]Jack Carr, "A Suggestion for the Treatment of Serial Correlation: A Case in Point," *The Canadian Journal of Economics*, Vol. 1, No. 2 (Toronto: May, 1972, pp. 301-306.

Table 5.19

RESULTS OF EMPIRICAL TESTS FOR RANDOM EFFECTS IN COTTON YIELDS, 1950 - 1974

MODEL 4.9: $\log YE_t = \alpha_0 + \alpha_1 t + \nu_t$

Cotton Zone	Intercept (α_0)	Regression Coefficient (α_1)	Skewness Statistic (Sk)[a]	T-Value	Durbin Watson	Degree of Freedom
East Buganda	2.41618	0.0049 (0.0031)	0.1834	1.5806	1.308†	23
Busoga	2.50231	0.0068 (0.0025)	0.1432	2.7200**	1.383†	23
Teso	2.43271	0.0076 (0.0026)	0.1633	2.9231***	1.278†	23
Lango	2.47877	-0.0069 (0.0034)	-0.6234**	-2.0294*	0.843††	23
West Nile	2.27200	-0.0076 (0.0034)	-0.5469**	-2.2353**	0.941††	23
Bunyoro	2.55544	-0.0068 (0.0034)	-0.6221**	-2.0000*	0.549††	23

[a]Skewness (Sk) $= \frac{\mu_3}{\sigma^3} = E\frac{(X-\mu)^3}{\sigma^3}$

***Coefficients are significant at the 0.01 level.

**Coefficients are significant at the 0.05 level.

*Coefficients are significant at the 0.10 level.

†The hypothesis of no positive serial correlation is accepted.

††The hypothesis of no positive serial correlation is rejected.

Note: Standard errors are in parenthesis.

conditions have had random effects on cotton yields in the study areas should be addressed. The results of the tests applied for this purpose are presented in Table 5.19.

The Durbin Watson test provided some evidence of the presence of positive serial correlation in yield data for Lango, West Nile, and Bunyoro. There was also significant skewness in the yield patterns.[1] This seems to suggest that there is a form of cyclic patterns such that yield values systematically lie below the trend and then above the trend. However, for the other zones--East Buganda, Busoga, and Teso--the Durbin Watson statistic provided no evidence of serial correlation. In these cases, the t-test for skewness was significant at the 0.05 level.

The implication of these two tests is that fluctuations in cotton yields for East Buganda, Busoga, and Teso may be regarded as purely random, while fluctuations in yields for Lango, West Nile, and Bunyoro, are likely to be caused by systematic production patterns within the farming practices of the peasant producers. These tests are important in yield analysis because they may provide some *a priori* information regarding the possible form and nature of the yield function.

Results of the Yield Functions

The empirical results of fitting the yield functions for cotton in linear, double-logarithmic and semi-logarithmic forms are presented in Tables 5.20 through 5.22. These results generally indicate that the

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[1]The ratio of the third moment around the mean to the third power of the standard deviation is frequently used as a measure of the degree of non-symmetry (skewness) of a distribution; $t' = \frac{\mu_3}{\sigma^3}$ where μ_3 = third moment and σ^3 = third power of standard deviation about the mean.

Table 5.20

RESULTS OF ESTIMATED YIELD FUNCTION

LINEAR MODEL: $YE_t = \beta_0 + \beta_1\overline{YE}_t + \beta_3 WE_t + \beta_3 t + \mu_t$

Cotton Zone	Estimated Coefficients[a]				R^2	DW[b]	F-Value
	Intercept	$\overline{YE}_t$	WE_t	t			
East Buganda	-31.02194	1.0275*** (0.1832)	0.1352 (2.3924)	2.0700 (2.2881)	0.6292	2.935[††]	10.75
Busoga	-140.70519	1.1009*** (0.2042)	0.9539 (2.6448)	0.7951 (3.3258)	0.6808	3.148[††]	13.51
Teso	-232.52293	1.0180*** (0.1973)	2.3706 (3.8881)	-0.6754 (2.7955)	0.7276	3.182[††]	16.92
Lango	-187.91564	1.1959*** (0.1534)	1.2643 (1.9059)	1.8846* (1.1199)	0.8164	2.241[†]	28.15
West Nile	54.49450	0.8408*** (0.2427)	0.3554 (2.4533)	1.3501 (1.1446)	0.6566	2.866[††]	12.11
Bunyoro	60.48515	1.1910*** (0.1227)	-1.0577 (1.0193)	1.7666* (1.1878)	0.8540	2.801[††]	37.03

[a]Standard errors are in parentheses.

[b]Durbin Watson statistic.

***Coefficients are significant at the 0.01 level.

**Coefficients are significant at the 0.05 level.

*Coefficients are significant at the 0.10 level.

[†]The hypothesis of no serial correlation is accepted.

[††]Tests for serial correlation are inconclusive.

three-year moving average of past yields, which may be taken as a measure of trend and thus of the "level of technology," constitutes the most important variable affecting annual variations in cotton yields in all the study zones. The other variables of "rainfall" (used as a proxy for weather conditions) and "time" did not contribute greatly to the overall level of significance of the estimated functions.[1]

In the linear form of the postulated model, the three hypothesised variables, the "three-year moving average of past yields" (YE_t), "time" (t), and "rainfall" (WE_t), explained some 63, 69, 73, 82, 66, and 85 percent of the variation in cotton yields in East Buganda, Busoga, Teso,Lango, West Nile, and Bunyoro, over the years from 1950 to 1974. The variable "three-year moving average of past yields" alone accounted for over 60 percent of the 63 to 86 percent of the total explained variation in yields with this function. Its estimated coefficients were in all cases significantly different from zero at the 0.01 level and over. The Durbin Watson test for the presence of autocorrelation in the yield data provided inconclusive evidence for all zones. The results of the linear model are presented in Table 5.20.

When the double-logarithmic formulation of the yield model was applied to the data, the estimated functions for Lango, West Nile, and Bunyoro, improved slightly (see Table 5.21). Those zones for which this improvement in the fitting of the model applied are the same zones which

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[1]The rainfall indices used in this analysis are based on the annual rainfall data recorded in the study zones. Thus the variable (WE_t) might not have reflected the actual crop-water requirement. Changes in rainfall during the cotton growing season would have been a more accurate specification of the variable (WE_t) than would the annual rainfall.

Table 5.21

RESULTS OF ESTIMATED YIELD FUNCTION

DOUBLE-LOG MODEL: $\log YE_t = \log\beta_0 + \beta_1 \log\overline{YE}_t + \beta_2 \log WE_t + \beta_3 \log t + \mu_t$

Cotton Zone	Estimated Coefficients[a]				R^2	DW[b]	F-Value
	Intercept	$\log\overline{YE}_t$	$\log WE_t$	$\log t$			
East Buganda	-0.37471	0.8941*** (0.1635)	0.3121 (0.6966)	0.0279 (0.0526)	0.6148	2.803††	10.11
Busoga	-0.87431	1.0608*** (0.2563)	0.3574 (0.5988)	0.0037 (0.0714)	0.6409	3.077††	11.30
Teso	-0.69698	1.0414*** (0.1810)	0.3006 (1.0887)	-0.0143 (0.0528)	0.7023	3.162††	14.94
Lango	-1.95323	1.1482*** (0.1253)	0.7852* (0.6132)	0.0490 (0.0351)	0.8455	2.260†	34.66
West Nile	0.27676	0.6547*** (0.0214)	0.2326 (1.1243)	0.0529 (0.0449)	0.6980	2.745††	14.64
Bunyoro	0.52328	1.1032*** (0.0967)	0.3889 (0.3220)	0.0425* (0.0282)	0.8947	2.660††	53.83

[a] Standard errors are in parentheses.

[b] Durbin Watson statistic.

***Coefficients significant at the 0.01 level.

**Coefficients significant at the 0.05 level.

*Coefficients significant at the 0.10 level.

†The hypothesis of no serial correlation is accepted.

††Tests for serial correlation are inconclusive.

evidenced cyclic patterns in cotton yields, with the earlier tests. This feature may perhaps be caused by systematic and periodic tendencies within the farming practices of the growers which are described by the semi-logarithmic and double-logarithmic formulations of the model. The estimated coefficients of the variable "three-year moving average of past yields" were significantly different from zero at the 0.01 level and over in all zones. However, the estimated coefficients for the variables of "time" and "rainfall" were not significantly different from zero. Tests for serial correlation indicated inconclusive evidence.

The semi-logarithmic formulation generated generally similar results to those obtained by the application of the double-logarithmic formulation to the data. These results are summarised in Table 5.22. The variable "three-year moving average of past yields," constituted the most important variable in explaining the annual variation in cotton yields. Its estimated coefficients maintained a level of significance at the 0.01 level and over. The estimated coefficients of the variable of "rainfall" for Bunyoro was significant at the 0.05 level, but negatively related to the dependent variables of the yield of cotton. All coefficients of determination were significant as measured by the F-test at the 0.05 level. There was evidence of autocorrelation in the data for Lango and Bunyoro; the tests for the other zones were inconclusive.

If the variable of "three-year moving average of past yields" is acceptable as a measure of the level of technology, then the double-logarithmic form of the model suggests a strong relationship between this

Table 5.22

RESULTS OF ESTIMATED YIELD FUNCTION

SEMI-LOG MODEL: $\log YE_t = \beta_0 + \beta_1 \overline{YE}_t + \beta_2 WE_t + \beta_3 t + \mu_t$

Cotton Zone	Estimated Coefficients[a]				R^2	DW[b]	F-Value
	Intercept	$\overline{YE}_t$	WE_t	t			
East Buganda	1.94106	0.0015*** (0.0003)	0.0007 (0.0036)	0.0019 (0.0034)	0.6210	2.830††	10.38
Busoga	2.07646	0.0011*** (0.0002)	0.0005 (0.0030)	0.0022 (0.0037)	0.6489	3.162††	11.71
Teso	1.99497	0.0025*** (0.0003)	0.0011 (0.0049)	-0.0015 (0.0035)	0.6925	3.091††	14.26
Lango	1.29654	0.0013*** (0.0002)	0.0045 (0.0039)	0.0027 (0.0023)	0.8184	2.364†	28.54
West Nile	1.94363	0.0021*** (0.0006)	-0.0008 (0.0058)	0.0017 (0.0027)	0.6837	2.618††	13.69
Bunyoro	2.29389	0.0016*** (0.0002)	-0.0027** (0.0015)	0.0002 (0.0017)	0.8581	2.295†	38.29

[a]Standard errors are in parentheses.

[b]Durbin Watson statistic.

***Coefficients are significant at the 0.01 level.

**Coefficients are significant at the 0.05 level.

*Coefficients are significant at the 0.10 level.

†The hypothesis of no serial correlation is accepted.

††Tests for serial correlation are inconclusive.

variable and the respective yield changes. The magnitudes of yield response with respect to this variable were 0.8941, 1.0608, 1.0414, 1.1482, 0.6547, and 1.1032 for East Buganda, Busoga, Teso, Lango, West Nile, and Bunyoro respectively. These estimates suggest that if improvements in production techniques are adopted, they may bring about significant increases in cotton yields and hence realised output.

Discussion of the Realism, Consistency, and Validity of the Acreage Response Models

The previous sections of this chapter involved the presentation of the empirical results of the acreage and yield functions. Estimates of the acreage elasticities and coefficients of adjustment were presented. This section discusses the realism, consistency, and validity of the results. In evaluating the results, emphasis is given to the purpose of the study and to the possible economic implications of the signs of these estimated coefficients which were significant at the 0.10 level and higher levels of significance.

As stated in Chapter I, this study addressed itself to the analysis of the acreage response functions for cotton for the selected study zones. The pertinent objective is to determine the apparent causes of the declining supply levels of cotton and to attempt to draw up possible solutions to this problem. In view of this, the testing of the postulated acreage response models has a two-fold purpose. In the first place, the results of these may assist economists in formulating judgements; secondly, response models are intended, as noted, to be prescriptive and predictive, by placing some light upon the probable consequences of future changes in the dependent variable involved in the model

construction. The following discussion explores whether or not the empirical results of the analysis provide a means of meeting the desired objectives.

Consistency with Economic Theory

Table 5.23 summarises the signs on the estimated coefficients of the major independent variables of the acreage response models. These are the lagged price (P_{t-1}) paid to growers for cotton, the prices of staple food crops (PF_{t-1}) lagged one year, and the prices of other selected food crops (PZ_{t-1}) lagged one year. The level of significance of the estimated coefficients of those variables is indicated in the same summary-table. This information is provided for the linear, double-logarithmic, and semi-logarithmic forms of models.

The estimated coefficients of the price variable (P_{t-1}) were consistently positive for all models. This feature is consistent with economic theory. It is expected that growers will commit more land to cotton production when cotton prices are relatively high or increasing, than when prices are relatively low or decreasing. The relatively small magnitude of the coefficients of the variable of price of cotton, which applied in most cases, is consistent with the coefficients estimated in similar studies of acreage response. Thus, the signs and the size of the estimated coefficients of the price variable (P_{t-1}) agree with those expected for this agricultural commodity. At the 0.10 level of significance, the estimated coefficients of the variable of cotton price were significantly different from zero for all the eleven model formulations in respect of East Buganda and Lango, and for ten of the eleven model formulations in the cases of West Nile and Bunyoro. Although the

Table 5.23

COMPARISON OF SIGNS ON THE ESTIMATED COEFFICIENTS OF PRICE VARIABLES AND THEIR RESPECTIVE SIGNIFICANCE LEVELS

Price Variable and Commodity		Linear Model				Log-Log Model			Semi-Log Model				Number of Significant Cases at ≤ 0.10
		4.5	4.6	4.7	4.8	4.5	4.6	4.7	4.5	4.6	4.7	4.8	
Price of Cotton (P_{t-1})													
East Buganda	Cotton	(+)**	(+)***	(+)**	(+)*	(+)***	(+)**	(+)**	(+)***	(+)**	(+)**	(+)**	11
Busoga	Cotton												0
Teso	Cotton												0
Lango	Cotton	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***	11
West Nile	Cotton	(+)***	(+)*	(+)*	(+)***	(+)***	(+)*	(+)**	(+)***		(+)**	(+)***	10
Bunyoro	Cotton	(+)***	(+)**	(+)**	(+)**	(+)**	(+)**	(+)**	(+)***		(+)*	(+)*	10
Price of Staple Food Crops (PF_{t-1})													
East Buganda	Bananas		(+)**	(+)*	(+)**								3
Busoga	Bananas												0
Teso	Finger Millet			(-)**		(-)**	(-)*				(-)*		4
Lango	Finger Millet	(+)**	(+)**		(+)**			(+)**	(+)**	(+)***	(+)*	(+)**	8
West Nile	Cassava	(+)**	(+)**	(+)**	(+)***	(+)*	(+)**	(+)***	(+)**	(+)*	(+)*	(+)**	11
Bunyoro	Finger Millet	(+)*	(+)*		(+)*								3
Price of Other Food Crops (PZ_{t-1})													
East Buganda	Sweet Potatoes												0
Busoga	Groundnuts	(+)*	(+)*	(+)*	(+)*								4
Teso	Groundnuts					(+)*	(+)*	(+)*					3
Lango	Groundnuts	(-)*					(-)*		(-)***	(-)*	(-)***	(-)*	6
West Nile	Finger Millet	(-)*	(-)**	(-)*				(-)*		(-)**	(-)*		6
Bunyoro	Groundnuts						(-)*						1

***Estimated coefficient significant at the 0.01 level.

**Estimated coefficient significant at the 0.05 level.

*Estimated coefficient significant at the 0.10 level.

Note: (+) indicates positive relationships.

(-) indicates negative relationships.

the coefficients of this price variable (P_{t-1}) for the Busoga and Teso acreage response functions were not significant, the signs were consistently positive as expected from economic theory (see Table 5.23).

The relationships between cotton acreage and the prices of staple food crops (PF_{t-1}) were, in a number of instances, as expected. The estimated price coefficients for bananas in East Buganda, finger millet in Lango and Bunyoro, and cassava in West Nile, were positive, suggesting that the relationship of these crops with cotton is not competitive in these zones. However, the coefficients of the price variable for bananas were significant at the 0.10 level only in the case of the linear model formulation. The coefficient of the price variable for finger millet and cassava in Lango and West Nile respectively were significantly different from zero in most cases. Although the prices of bananas and finger millet in Busoga and Teso were negatively related to cotton acreage, only in the case of Teso did the estimated coefficients of the price variable for finger millet suggest a competitive relationship between this crop and cotton.

In summary, the major staple food crops in East Buganda, Lango, West Nile, and Bunyoro, do not seem to compete with cotton in the use of resources at the farm level. This does not, however, appear to be the case with Teso and, perhaps, Busoga. Although finger millet is a staple food crop for Teso Zone, it is substantially used for preparing local brews popularly known as "malwa"[1] in the northern and eastern provinces of Uganda. Because of this additional use, the grain has become

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[1]"Malwa" is a native beer brewed from finger millet (Eleusine *coracana*).

highly commercialized in local markets. About 20 to 30 percent[1] of the total production goes to local markets. Thus, in the face of the repressive cotton prices, finger millet could easily form a competitive source of income for the cotton producers, and hence the negative sign on the coefficients of the price variables of finger millet.

The negative relationship between cotton acreage and the prices of sweet potatoes in East Buganda, groundnuts in Lango, Teso, and Bunyoro, and finger millet in West Nile, was consistent between all model formulations. The estimated coefficients of these price variables in the above zones were significant at the 0.10 level. This feature indicates that there is a competitive position between cotton and the production of those crops. This relationship may be due to the fact that these crops are less labour-intensive, and appear to fetch prices which are relatively more attractive to the growers than is cotton. It is apparent that farmers, during the period under study, have shifted land resources from the production of cotton to that of groundnuts, sweet potatoes, and finger millet, in those zones. This conclusion may, however, not strictly apply to sweet potatoes in East Buganda, since the estimated coefficients of the price variable for sweet potatoes were not significantly different from zero. The prices of groundnuts in Busoga were positively related to cotton acreage and this relationship was significant only in respect to the linear formulation of the models.

The estimated coefficients of the variable of land under cultivation are characterised by consistently negative signs and, in most

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[1]Uganda Department of Agriculture, *Report of Annual Agricultural Statistics 1967/68 and 1968* (June 1969):120.

cases, these coefficients are significant at the 0.10 level and over. However, the estimated coefficients of the variable "land under cultivation" for Teso were consistently positive but not significantly different from zero. The negative relationship between cotton acreage and land under cultivation may suggest that the land tendure systems prevailing in Uganda may be considered to be a factor limiting cotton expansion in terms of increased acreages. This conclusion seems to be supported by the negative coefficients on the dummy variable (DC_t), since this programme was intended to increase production through expansion of cotton acreages. The relationship between the amount of land available to the producer and crop production expansion is crucial in policy formulation, as it dictates the nature of production strategy--the degree to which increased production is to be achieved, either through expansion of land available for crops or through improvements in crop yields per unit area. The estimated coefficients of the variable "world price of cotton" (W_{t-1}), though positive for all model formulations, were not significantly different from zero. This reinforces the suggestion that cotton producers do not respond to price changes in international markets. This result appears to be consistent with the earlier conclusion by Ady[1] with respect to cocoa growers in Nigeria and Ghana.

Realism of the Results

The results which were outlined in this chapter are based on past changes in cotton acreages and other variables considered. The changes

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[1]Peter Ady, "Supply Functions in Tropical Agriculture," *Oxford Economics and Statistical Bulletin*, pp. 157-188.

in cotton acreage data reflect farmers' behaviour in response to changes in economic and other factors.

The data outlined in Chapter IV indicated that cotton planting has, during the period from 1950 to 1974, been declining on the agricultural holdings. Prices paid to growers for cotton in both current and real terms persistently declined during the same period. There has been, however, phenomenal growth in both the acreages of food crops and their prices. It is important to note that all producers are concerned about the adequacy of returns from their labour and capital investment and they are particularly concerned about the necessity of maintaining their living standards with earnings from their enterprises. Thus, the declining levels of cotton supplies must be positively associated with the repressive prices paid to growers for cotton. Increases in the acreages of food crops are commensurate with the increasing prices of these crops. These associations are consistent with the results which were generated by this analysis. The significance of the estimated coefficients of the variable of price paid to growers for cotton (P_{t-1}) indicates that Ugandan cotton growers respond rationally to market conditions for cotton.

Another aspect of the realism of the supply response functions tested is given by the resulting pattern of acreage elasticities with respect to price. The magnitude of these elasticities is strongly associated with the existence of the more profitable production alternatives. The results appear to provide strong support for the hypothesis that elasticities of supply tend to be highest for commodities which comprise a small proportion of farm production, have alternatives which are

substitutable at farm level, and have relatively short production periods. Despite the fact that regression techniques may not fully account for all the effects of changes in the decision-making environment, the estimated coefficients generated by this analysis reflect the realistic historical performance and structure of the Uganda cotton production sector.

Validity of the Results

The validity of any econometric model can be affected by misspecification of the mathematical form of the model as well as to improper specification of the explanatory variables. The reliability, consistency, and accuracy of the data used are other factors which influence the validity of the estimated model. For accurate specification of supply response models which may depict the behaviour of producers in peasant agricultural economies, certain "critical distinctions" are necessary. Wharton, Jr. has outlined these distinctions as follows:

> 1. . . . Acreage response must be distinguished from yield response to economic incentives. Since most studies have tended to use land as the dependent variable, a distinction must be made between the farmer's allocation of land and non-land resources in response to price. An increase in the acreage devoted to a crop or the addition of new land must be separated from an increase in output from the existing unchanged acreage.
>
> 2. . . . The elasticity of response by agriculture *as a whole* must be separated from that of a single crop. Most studies have involved a single commodity or a limited number of commodities in reaction to changing economic incentives, which is not the same as response of all agricultural commodities.
>
> 3. . . . Distinctions must be made to varying *lengths of time* involved in the estimated elasticities. Length of run and the time periods in adjustment to economic stimulus are critical.
>
> 4. . . . The elasticity of *farm production* as a whole must be distinguished from the elasticity of a *market surplus*. This

distinction is particularly important under conditions of subsistence production.[1]

As stated in Chapter III, this study was based on the factors expected to constitute the most important data in determining aggregate supply in a subsistence economy. The distinctions outlined above were considered, particularly distinctions 1, 2, and 3. Another important implication emphasised in this study is that supply response to price changes cannot be analysed in isolation, but must be analysed in the context of relative product prices as the signals which elicit behavioural responses. This feature is particularly important in areas where mixed cropping is practised.

Accuracy of Statistical Material and Other Limitations of the Study

In addition to the theoretical limitations which constrain the use of ordinary least squares in supply analysis (which is based on the Nerlovian adjustment hypothesis), the study was also constrained by the accuracy of statistical material and multicollinearity problems. These limitations are discussed below.

The scarcity of data appropriate for economic analyses in most developing countries has indeed hampered the quest for quantitative analyses of supply and demand relationships in those countries. The problem of inaccurate data is not non-existent in Uganda. The major source of th. data used in this analysis is the Planning Unit of the Ministry of

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[1]Clifton R. Wharton, Jr., "Supply Relationships in Peasant Agriculture," *Subsistence Agriculture and Economic Development*, ed. Clifton R. Wharton, Jr. (Chicago: Aldine Publishing Company, 1970), pp. 229-231.

Agriculture and Forestry. The methods which are used to compile and analyse these statistics are not entirely free from errors of accuracy and consistency. Some of the data series, for example, were incomplete. These gaps were filled by assuming approximated growth rates in certain variables. The price data were deflated by the cost of living index--an assumption which may be considered inappropriate in supply studies. Thus, complete accuracy, reliability, and consistency of the statistical material used in this analysis may not be guaranteed.

In the regression model which was applied in this analysis, successive disturbances might have been correlated for various reasons, thereby violating the assumption of independence of the error terms. This assumption is important in the application of the Ordinary Least Squares method. Autocorrelation may arise because of the faulty functional form of the assumed model, the omission of variables from the analysis, and the lagged effect of temporary shocks distributed over a number of time periods.[1] Attempts to correct this problem of autocorrelation in the models were not successful because of the presence of a lagged dependent variable among the independent variables (see Appendix V). Most of the tests for autocorrelation were, however, inconclusive. This implies that the existence of serially correlated disturbances cannot be eliminated from this analysis.

In time series data, multicollinearity is a prevalent phenomenon in the observations of independent variables. When independent variables are highly correlated, not only do the estimated regression coefficients

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[1]David S. Huang, *Regression and Econometric Methods* (New York, London, Sydney, Toronto: John Wiley and Sons, Inc., 1964) pp. 135-36.

tend to be imprecise--being erratic from sample to sample--but the true regression coefficients tend to lose their meaning. In this analysis, the variable "time" was found to be highly correlated with most independent variables (the price of cotton paid to producers, the world price of cotton, and the prices of other crops). In some cases, the level of the partial correlation coefficients suggested extreme multicollinearity. In preliminary analysis, the inclusion of the variable "time" in the Estimating Equations 4.5 to 4.8, resulted in most of the estimated coefficients being non-significant. Thus, the variable of time was omitted entirely from the Estimating Equations 4.5 to 4.8.

Summary and Conclusion

This chapter has presented the results of the analysis, and has briefly discussed the consistency, realism, and validity of the estimating equations, including an evaluation of the data and of the other limitations of the study. Of particular interest in this analysis, however, is the significance of the estimated coefficients of the variable "price paid to growers for cotton," and their consistency with economic theory. The elasticities of acreage with respect to the price paid to growers for cotton appear to be comparable to elasticities derived in similar studies elsewhere. Thus, the zonal acreage response functions presented and discussed in this chapter seem to emphasise that relative prices are appropriate signals that elicit behavioural responses of cotton growers in the zones under study. These findings have very important policy implications. In the next chapter, the summary, conclusions, and some policy implications are discussed.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

This study focused on the relationship between the acreage planted to cotton and the levels of prices paid to cotton producers in Uganda. The secondary feature was an examination of whether or not changes in rainfall in Uganda have had random effects on cotton yields. The period of study was from 1950 to 1974, a time span of twenty-five years. Trends in cotton acreage and production were described and analysed for the study period. In the analysis of production trends, special emphasis was placed on competition between cotton and food crops at the farm level. This was necessary because the type of competititon among crops has an important bearing, not only on the acreage response elasticity, but also on the variables which may be included in the response models. Changes in the prices of cotton and food crops for the period from 1950 to 1974 were discussed and analysed. Because the relative importance of different alternatives to cotton in Uganda tend to differ greatly in various cotton areas, this study considered six zones which are relatively small agricultural divisions--East Buganda, Busoga, Teso, Lango, West Nile, and Bunyoro. The staple food and other selected food crops which provide substantial income to the cotton producers are distributed in these cotton zones as is shown in Appendix VI.

The analysis of the causes of the declining levels of cotton supplies involved the estimation of acreage response functions for the Cotton Zones and the derivation of short-run and long-run acreage response elasticities and coefficients of adjustment. Econometric analyses were applied to time series data and the effects of the price of cotton, the prices of other commodities, and the effects of other variables on the average area under cotton per 100 agricultural holdings were estimated. The approach taken was to use the Nerlovian dynamic supply model, which has its foundation in the neoclassical economic theory of investment. An advantage of this formulation of supply response is that it provides for estimation of short- and long-run supply responses.

The analysis of the yield data explored the concepts of positive autocorrelation and skewness. These concepts were used to test whether or not the influence of weather conditions demonstrated random effects on cotton yields in the Study Zones.

The choice of variables in both the postulated acreage response and yield functions was based on the theory of supply and on *a priori* knowledge of the factors which appear to affect cotton production in the study areas. The Ordinary Least Squares (OLS) technique was applied in each case to estimate the relationships between the dependent variables and the explanatory variables. The relationships were tested in linear, double-logarithmic, and semi-logarithmic formulations.

The results indicated that during the period from 1950 to 1974, the variable "price paid to growers for cotton" was the most important determinant of the area under cotton on agricultural holdings. The estimated coefficients of this variable were significant at high levels for

almost all Zones and model formulations. This variable alone accounted for 45 to 53 percent of the 57 to 95 percent of total explained variation in the estimated acreage response functions. The prices of staple food crops in Busoga and Teso were negatively associated with the area under cotton, while prices of similar food crops in East Buganda, Lango, West Nile, and Bunyoro were positively related to area under cotton. It thus appears that cotton faces competition from finger millet and bananas in Teso and Busoga respectively. For all Zones except Busoga, the prices of other selected food crops appear to have a negative relationship with cotton acreage, though in only a few cases were the estimated coefficients of these price variables highly significant. The estimated coefficients for the variable "world cotton price" were not significantly different from zero. These coefficients, however, maintained a positive association with the dependent variable. The estimated coefficients of the dummy variable (DC_t) were not significantly different from zero. The signs on these coefficients were negative.

The estimated short-run acreage elasticities with respect to cotton price varied from Zone to Zone. East Buganda and Bunyoro had the largest acreage elasticities. The magnitude of elasticities in these two Zones varied between 0.5266 and 0.9719. The estimated acreage elasticities for Lango and West Nile were almost equal in value and ranged between 0.2616 and 0.4957. The smallest elasticities were obtained for Busoga and Teso Zones and these ranged between 0.1323 and 0.1603. Though relatively more elastic, the long-run estimates followed a similar pattern. The East Buganda Zone had the largest estimated acreage elasticities, ranging between 1.3214 and 2.8729 in magnitude. Estimates for

Bunyoro varied between 0.7302 and 0.9369, and those for the Busoga, Lango, and West Nile Zones fell between 0.3462 and 0.7300. As in the case of the short-run response, Teso had the smallest estimated long-run acreage elasticities. The double-logarithmic formulation tended to generate more responsive acreage elasticity estimates than did the linear formulation.

The yield tests suggested that fluctuations in cotton yields in the Lango, West Nile, and Bunyoro Zones may not be entirely attributable to random factors. It appears that in these areas fluctuations in yields tend to persist over time causing cyclicities over a trend value. This conclusion was supported by the results of the estimated yield functions for the Lango, West Nile, and Bunyoro Cotton Zones. The application of a double-logarithmic model formulation to yield data from these Zones gave a better fit to the data than did the linear and semi-logarithmic model formulations. The variable of the three-year moving average of past yields, taken as a measure of the level of technology, accounted for 55 to 60 percent of the 61 to 89 percent of total variation in cotton yields for the various Zones.

Conclusions

The data which have been examined and analysed, while subject to limitations of accuracy, consistency, and reliability, do enable some conclusions to be drawn:

1. During the period from 1950 to 1974, the share of cotton's value in Uganda's economy substantially decreased. This decrease was commensurate with the corresponding declining level of cotton production

on the farmers' agricultural holdings. Average production and the area under cotton per agricultural holding persistently declined at the rate of 1.5 and 1.1 percent per year respectively. The prices paid for cotton trended downward. In real money terms, the price of cotton paid to growers declined by 99 percent during the study period, representing an annual decline of about 3.0 percent. The downward trend in the average area committed to cotton per agricultural holding closely followed the trend in actual prices received by the cotton growers.

However, food crop production more than doubled during the period of study. The total acreage of food crops grew at a rate of 3.0 percent per year and annual production per caput remained almost constant at 1,314 kilograms. The increases in food production appear to have been largely due to expansion in acreage rather than to increases in yields (see Appendix IV).

2. The hypothesised Nerlovian dynamic supply response model used in this analysis seems to have satisfactorily explained much of the variation in the dependent variable "average area under cotton per 100 agricultural holdings." Examination of the coefficients of determination obtained from the estimated acreage functions suggests that for most of the Cotton Zones, the estimating equations explained a considerable proportion of the variability in the acreage and were significant at the 0.05 level of significance.

3. The results of this and an earlier related study,[1] indicate that the acreage committed to cotton on farmers' agricultural holdings

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[1]G. Alibaruho, "Regional Supply Elasticities in Uganda's Cotton Industry," *East African Economic Review*.

is responsive to price changes. The degree of responsiveness, however, varies from Zone to Zone.

4. The estimated elasticities of acreage with respect to prices paid to growers for cotton ranged between 0.1323 and 0.9719 for the short-run, and between 0.2616 and 2.8729 for the long-run. The pattern of response of acreage to price movements was related to the existence of profitable alternative crops. The acreage elasticities tended to be highest for those Zones--East Buganda, Bunyoro, Lango, and West Nile--which have alternative economically-attractive cash crops that may be substituted in production at the farm level. The elasticity of acreage tended to be lowest in those areas--Teso--which lack any cash crop other than cotton.

5. The negative relationship between cotton acreage and some of the staple and other selected food crops--bananas in Busoga, sweet potatoes in East Buganda, and finger millet in Teso and West Nile--indicates that policy decisions affecting the prices of these crops may have some impact on the acreage under cotton. However, the extent to which these crops may be regarded as competitive cannot be readily assessed, since many of these cross-elasticities were based on estimated coefficients which were not significant at high levels.

6. The coefficients of adjustment (γ) estimated from the acreage response functions suggested that cotton growers in the Study Zones respond to and then adjust the cotton acreages to changes in price levels.

7. Cotton yields in Lango, West Nile, and Bunyoro, show a fairly evident increasing trend over time and fluctuations in these yields may not be entirely associated with random effects but may show evidence of cyclicity.

Policy Implications of the Study

The results of this analysis have indicated that cotton acreage responds significantly to changes in its own price. Price changes for cotton should be regarded as appropriate signals that elicit behavioural responses in smallholder cotton production. This is consistent with the feature that a considerable proportion of the decline in the levels of cotton acreage during the period from 1950 to 1974 was explained by the levels of prices paid to growers for cotton. The magnitude of the estimates of the short-run and long-run elasticities of acreage with respect to price indicates a fairly responsive degree of sensitivity of cotton acreage to changes in its own price.

The overall implication of this analysis is clear. If it is deemed desirable to increase cotton production in Uganda, the price mechanism can be used as an important policy instrument toward that goal. The relative decline of cotton production and exports in the 1970's can be attributed, in part, to the declining real cotton prices paid to producers prior to 1973 and, more recently, to the fact that real cotton prices, while increasing of late, have increased less than food crop prices.

The decision as to whether or not cotton production should be expanded in Uganda (and a more positive price policy used toward that end) is a much more complicated policy decision than this research can directly address. In part, the relative decline in cotton production and exports has been a rational adjustment on the part of Uganda cotton producers to the historical decline in the real prices of cotton (and the even greater decline in real cotton prices relative to prices of food

crops). Any decision to stimulate cotton production would have to take into consideration a multitude of factors. Such factors include the possible distortion in terms of trade between agriculture and other sectors of the economy (hence, generating artificially-depressed prices for agricultural commodities, including cotton) which is so often associated with import substitution policies and the overriding foreign exchange constraint which so dominates development strategy that expansion of cash crops, even if "inefficient" in terms of resource allocation, might assist in overcoming that bottleneck. Further, the relative balance between food and cash crops, given the need to feed an increasing population, would need to be considered. An additional question would concern the relative importance of cotton versus coffee in any cash crop expansion, given such external factors as potential cartelization among coffee producers and the probable greater relative attractiveness of cotton versus synthetics following the energy crisis. Other factors which would need to be considered include the relationship between external and internal prices for cotton, particularly where marketing boards might be used to generate an "agricultural surplus" through direct or indirect export taxes on cotton; the use of expanded cotton production to deal with goals (beyond resource efficiency) such as income distribution among regions or income classes; and so on. In short, the question of the relative emphasis to be placed on expansion of the cotton sector is a complicated policy issue beyond the scope of this study. This study does, however, demonstrate that the prices paid to cotton producers are an effective instrument in inducing changes in producers' production decisions.

Need for Future Research

The considerable empirical work that has been done on acreage response in developing countries shows that the production of agricultural commodities in these countries is price responsive and that the form and direction of the response are consistent with price theory. The extent of the response in various regions within individual countries and for different commodities reflects some important policy implications and issues.

In a country like Uganda, which is predominantly agricultural in character, the short-run and long-run problems of income stabilization for the producers of export crops are partly related to the supply elasticities of the relevant commodities. There is, therefore, a need for frequent assessment of price policy. Such exercises require reliable empirical knowledge about the degree of responsiveness of supply to changes in economic incentives.

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APPENDICES

APPENDIX I

CONTRIBUTION OF AGRICULTURE TO THE GROSS DOMESTIC PRODUCT*

Industry	1966	1967	1968	1969	1970	1971	1972	1973[†]	1974[§]	1970 to 1973	1970 to 1974	1970 to 1974 Growth Rate % pg
	Ug. Shillings in Millions									% Change		
Monetary Economy												
Agriculture	1,480	1,478	1,445	1,746	1,778	1,629	1,772	1,866	1,649	+ 4	- 8	-1.4
Cotton Ginning, Coffee Curing, and Sugar Manufacture	96	95	94	113	114	99	95	92	75	-10	-45	-9.6
Forestry, Fishing, and Hunting	52	59	65	75	81	92	99	102	104	+26	+41	6.5
Mining and Quarrying	104	99	110	118	119	112	100	72	69	-40	-43	-12.1
Manufacture of Food Products	49	48	56	57	61	57	63	57	52	- 7	- 8	-3.5
Miscellaneous Manufacturing	359	378	393	432	456	482	482	454	467	- 1	+ 2	0.7
Electricity Production	68	78	84	86	92	100	99	99	97	+ 8	+ 5	1.4
Construction	69	84	96	109	92	95	77	67	78	-28	- 5	-3.0
Commerce	811	805	844	900	891	940	819	719	702	-10	-21	-8.1
Transport and Communication	225	248	266	291	276	323	332	298	317	+ 8	+15	3.9
Government	371	382	382	385	447	566	627	634	671	+42	+50	11.0
Miscellaneous Services	351	388	407	447	453	479	502	460	425	+ 2	- 6	-1.4
Rents	213	212	212	238	232	272	240	220	240	- 6	+ 3	-2.9
Total Monetary Economy	4,248	4,354	4,454	4,997	5,092	5,246	5,307	5,140	4,947	+0.1	- 3	-0.7
Non-Monetary Economy												
Agriculture	1,511	1,566	1,634	1,765	1,763	1,803	1,928	1,972	2,010	+12	+14	3.3
Forestry, Fishing, and Hunting	132	137	141	145	149	157	163	168	174	+13	+16	3.9
Construction	27	28	28	29	30	32	33	33	34	+10	+13	3.2
Owner-Occupied Dwellings	201	211	202	235	245	254	261	265	274	+ 9	+12	2.6
Total Non-Monetary Economy	1,871	1,942	2,005	2,174	2,187	2,246	2,385	2.438	2,490	+11	+14	3.2
Gross Domestic Product	6,119	6,297	6,459	7,171	7,279	7,492	7,692	7,578	7,439	+ 4	+ 2	0.5
Population (in 000's)	8,431	8,768	9,118	9,456	9,767	10,256	10,461	10,704	11,063	---	---	2.5
Monetary GDP per Capita (SHS)	503	497	485	527	521	511	507	480	447	---	---	-4.3
Total GDP per Capita (SHS)	726	718	708	756	745	730	735	708	672	---	---	-2.7

*Gross Domestic Product (GDP) is based on 1966 prices.

[†]Estimate

[§]Provisional

SOURCE: Uganda Government, *Statistical Abstracts*, Various Issues; Uganda Government, *The Action Programme*, pp. 21-28.

APPENDIX II

COTTON PRODUCTION AND YIELD PER UNIT AREA (HECTARE) IN LINT BY ZONE
1950 - 1974

Year	Quantities of Lint (in tonnes)						Yield Per Hectare (in kgms)					
	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro
1950	8,132	13,911	12,900	4,911	914	1,970	67	114	98	84	49	115
1951	8,110	12,163	11,311	4,100	987	1,989	88	99	97	70	50	107
1952	7,914	10,901	13,214	4,691	1,001	1,990	103	91	106	78	53	104
1953	7,213	12,928	14,913	5,314	1,087	1,992	81	100	118	79	53	106
1954	6,910	12,362	13,000	5,913	1,143	1,981	72	107	111	98	57	102
1955	7,100	11,963	12,900	6,113	1,213	2,001	85	110	119	98	58	100
1956	6,913	12,362	11,300	6,712	1,369	2,113	93	98	98	107	64	99
1957	7,000	14,900	11,141	6,771	1,400	2,213	99	124	103	105	72	112
1958	7,132	13,212	11,046	6,789	1,411	2,193	91	134	103	106	73	111
1959	7,103	12,931	11,321	6,790	1,412	2,214	109	130	110	99	67	110
1960	7,326	12,800	11,300	6,211	1,413	2,110	145	133	105	105	65	106
1961	7,618	14,300	10,913	6,111	1,800	2,000	143	155	82	79	81	81
1962	3,424	8,120	9,163	6,523	1,213	1,914	67	98	72	84	53	85
1963	4,319	16,913	11,811	7,000	2,344	1,900	103	191	83	101	103	99
1964	5,414	16,928	12,100	7,413	1,941	2,413	112	198	134	103	79	163
1965	3,813	20,418	10,644	8,514	2,300	2,714	83	193	91	109	67	145
1966	3,329	20,714	14,911	7,616	2,514	2,914	88	173	93	107	75	157
1967	3,110	17,644	18,643	6,100	2,613	3,800	60	166	140	110	76	163
1968	2,440	11,023	13,411	7,014	2,014	3,211	56	98	91	74	49	117
1969	2,013	16,044	15,800	8,913	2,300	4,101	80	138	172	67	46	103
1970	2,611	11,900	22,511	6,093	2,613	4,400	98	138	178	72	39	118
1971	2,218	16,200	18,000	5,518	2,100	3,611	83	125	159	34	35	73
1972	2,632	17,791	14,713	6,813	1,713	3,201	151	130	183	36	32	53
1973	2,418	26,211	11,811	6,514	2,613	1,912	118	135	145	84	72	52
1974	2,013	14,523	8,100	5,317	1,812	1,093	96	151	123	97	84	75

SOURCE: Uganda Department of Agriculture, *Annual Agricultural Reports*, Various Issues (Entebbe: Department of Agriculture).

NOTE: Yield in 1 kilogram of lint = 0.33 x yield of 1 kilogram of seed cotton.

APPENDIX III

EXPECTED GROSS RETURN PER HECTARE IN MONEY AND REAL INCOME BY ZONE (in Ug. Shillings)
1950 - 1974

Year	Expected Gross Return per Ha (Money Income)							Real Expected Gross Return per Ha (Deflated by Cost of Living Index*)						
	Uganda	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro	Uganda	East Buganda	Busoga	Teso	Lango	West Nile	Bunyoro
1950	274	234	293	333	293	156	395	535	457	758	667	572	306	771
1951	336	296	333	330	235	174	351	645	559	634	633	451	334	673
1952	336	349	305	359	256	179	352	608	632	553	649	426	323	636
1953	294	277	342	400	272	180	363	490	452	570	666	425	300	606
1954	242	246	356	392	336	200	353	400	395	572	637	437	322	558
1955	399	348	449	495	401	235	408	502	525	579	746	505	354	616
1956	418	341	352	350	392	237	387	597	487	502	500	573	340	663
1957	275	374	455	397	394	260	420	392	533	649	555	553	371	600
1958	355	356	534	402	413	295	434	505	507	752	573	599	421	619
1959	315	344	425	345	310	209	345	441	492	595	493	434	293	494
1960	353	465	426	337	337	210	343	484	551	596	472	471	294	490
1961	307	530	695	300	290	300	300	415	717	940	406	392	405	407
1962	254	252	375	275	325	210	315	322	319	475	351	412	256	400c
1963	349	397	733	320	390	400	393	410	457	952	375	460	471	452
1964	330	423	666	457	353	257	628	359	458	794	496	392	279	679
1965	397	283	725	342	411	250	485	355	251	639	315	378	231	447
1966	422	330	693	392	415	297	590	441	345	455	410	434	393	617
1967	255	239	435	359	290	212	472	251	235	460	353	285	188	454
1968	293	146	291	370	221	151	349	291	140	295	356	212	145	335
1969	352	238	455	667	221	143	341	293	199	379	556	194	120	294
1970	327	326	485	643	259	143	425	254	254	393	521	210	116	344
1971	311	310	459	598	141	133	275	220	219	325	423	100	94	195
1972	429	566	497	695	135	120	200	313	413	353	507	99	98	146
1973	663	440	539	580	330	280	203	455	302	370	400	227	193	139
1974	702	472	747	612	495	414	373	446	300	475	400	316	253	237

*Cost of Living Index for low income groups in Kampala City (1965-66 = 100).

SOURCE: Uganda Department of Agriculture, *Annual Agricultural Reports*, Various Issues (Entebbe: Department of Agriculture).

APPENDIX IV

LEVEL OF CROP PRODUCTIVITY - MAJOR FOOD CROPS

Year	Yield per Ha in Kilograms								
	Bananas	Sweet Potatoes	Cassava	Finger Millet	Maize	Sorghum	Rice	Beans	Groundnuts
1960	8039	8600	8700	1300	1610	1470	880	680	910
1961	8020	8600	9200	1290	1640	1490	880	670	930
1962	8050	8300	8800	1280	1650	1480	880	710	930
1963	8090	8400	8700	1250	1590	1460	890	740	920
1964	8095	8300	8800	1280	1540	1470	890	700	930
1965	8065	8300	8700	1270	1650	1470	860	750	910
1966	8114	8700	8700	1270	1550	1470	880	720	920
1967	7960	8600	8700	1320	1560	1470	880	760	880
1968	8120	8500	8400	1280	1610	1480	860	740	920
1969	8317	8400	8600	1340	1630	1470	880	830	930
1970	8420	8400	8600	1340	1510	1480	890	750	920
1971	8329	8500	8900	1340	1520	1460	900	770	870
1972	8280	8600	8900	1330	1570	1450	880	800	890
1973	8333	8500	8400	1340	1330	1450	880	850	850
1974	8350	7600	8500	1000	1320	1460	870	830	840

SOURCE: Planning Unit, Ministry of Agriculture and Forestry, unpublished "Reports" (Entebbe: Statistics Section).

APPENDIX V

LIMITATIONS OF THE PARTIAL ADJUSTMENT MODELS

Partial adjustment models are the basis of distributed lag models. Generally, the partial adjustment model theorizes a gap between desired and realised levels with only a partial adjustment to this gap in any current period. This initial adjustment is partial rather than complete because of the existence of institutional or psychological constraints or because of the costs of adjustment.

In equation form a partial adjustment model can be represented as:

$$Y_t - Y_{t-1} = \lambda(Y_t^* - Y_{t-1}), \; 0 < \lambda < 1 \qquad \text{A1.0}$$

The parameter of primary interest is λ, the adjustment coefficient. The desired level is given as:

$$Y_t^* = \alpha_0 + \beta_1 X_t + \mu_t \qquad \text{A1.1}$$

Substituting for Y_t^* into the original structural equation, A1.0, we have:

$$Y_t - Y_{t-1} = \lambda(\alpha_0 + \beta_1 X_t + \mu_t - Y_{t-1}) \qquad \text{A1.2}$$

$$Y_t = \lambda\alpha_0 + \lambda\beta_1 X_t + (1 - \lambda)Y_{t-1} + \lambda\mu_t \qquad \text{A1.3}$$

where: $\lambda\alpha_0 = B_0$; $\lambda\beta_1 = B_1$; $1 - \lambda = B_2$, $\lambda\mu_t = \nu_t'$

Thus: $\hat{\lambda} = 1 - B_2$, which is the estimated coefficient of adjustment.

Under the partial adjustment hypothesis, Y_t would steadily rise or fall until long-run equilibrium Y^* is reached. For any increase in

the expected and actual level of economic incentives (prices), Y would follow a path such as that sketched in Figure A-1.

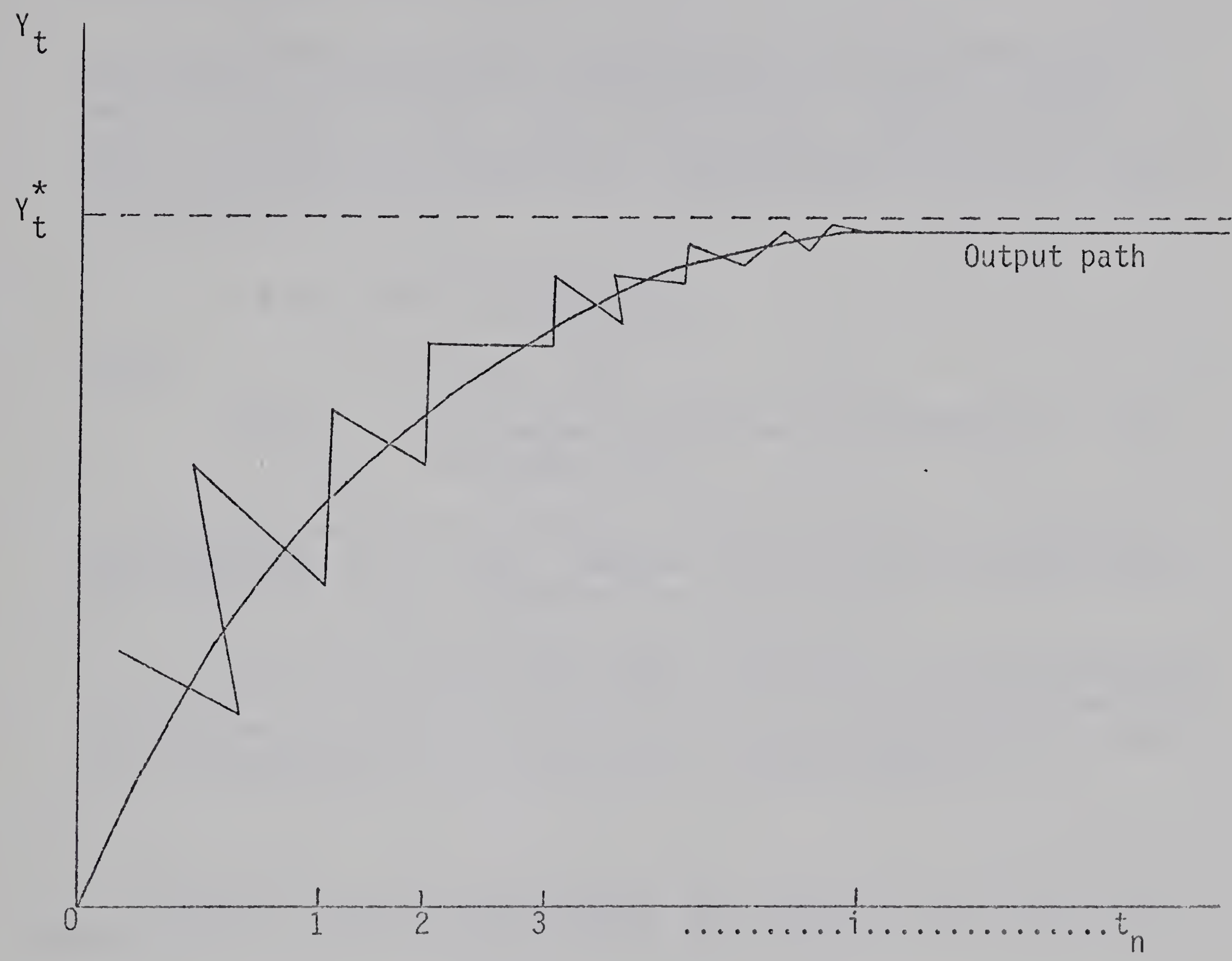

Figure A-1

Adjustment Process of Y_t to Long-Run Equilibrium of Y_t^* Over Time t in Response to the Level of Economic Incentives (Prices)

The change in output of Y to the equilibrium Y^* is distributed over time.[1]

Orr has noted the major difficulties with the Nerlovian partial adjustment model as:

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[1]Marc Nerlove, *The Dynamics of Supply: Estimation of Farmers' Response to Price*, pp. 61-62.

1. In general, Y_{t-1} and μ_t would be correlated due to their mutually high correlation to Y_t. This yields estimates of B_2 which are consistent but biased in small samples. The obvious remedy is to increase the sample size.

2. If there is serial correlation, then the estimates are inconsistent. The estimated standard errors are smaller than the actual standard errors. Note that there is a lagged dependent variable among the explanatory variables; the "h" statistic, rather than the Durbin Watson statistic, should be used to test for autocorrelation if $n \geq 30$.

$$h = \left(1 - \frac{\hat{\rho}}{2}\right)\sqrt{\frac{n}{1 - n\mathrm{Var}(B_{yt-1})}}$$

where: n = sample size

$\mathrm{Var}(B_{yt-1})$ = estimated variance on the coefficient of the variable, Y_{t-1}.

For the purpose of calculating the "h" statistic, $\hat{\rho}$ can be approximated by: $\hat{\rho} = 2 - \text{D.W.}$ However, "h" is a large sample statistic--its small sample properties are questionable.

3. The partial adjustment model assumes that the desired level of stock, Y_t^*, is solely a function of the level of another variable in the current period only, X_t. It is always appropriate to ascertain the applicability of the model to exact situations.[1]

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[1]Dale Orr, *Applied Econometrics* (Toronto: Institute for Policy Analysis, University of Toronto, 1977), pp. 134-135.

APPENDIX VI

DISTRIBUTION OF STAPLE AND OTHER SELECTED FOOD CROPS IN THE COTTON STUDY ZONES

Agricultural System	Cotton Zone	Food Crops	
		Staple	Other Selected
1. Banana-Coffee System	East Buganda	Bananas	Sweet Potatoes
2. Banana-Millet-Cotton Systems	Busoga	Bananas	Groundnuts
3. Teso System	Teso	Finger Millet	Groundnuts
4. Northern Systems	Lango	Finger Millet	Groundnuts
5. West Nile Systems	West Nile	Cassava	Finger Millet
6. Banana-Cassava-Millet Systems	Bunyoro	Finger Millet	Groundnuts

SOURCE: J. D. Jameson, ed. *Agriculture in Uganda*, 2nd Edition (Bungay, Suffolk: Oxford University Press, 1970), pp. 127-29.

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